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The Kent Incorporated Society for Promoting Experiments in Horticulture

IMPERIAL ... BIOLOGICAL
17 OCT 1942
INSTITUTE

ANNUAL REPORT

(TWENTY-NINTH YEAR)

1941

EAST MALLING RESEARCH STATION

Near MAIDSTONE

KENT

1st January, 1941 to 31st December, 1941

Free to Associate Members
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5/- post free
Great Britain only

Published
August, 1942

THE KENT INCORPORATED SOCIETY
FOR PROMOTING EXPERIMENTS IN
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PRINTED IN GREAT BRITAIN BY HEADLEY BROTHERS
109 KINGSWAY, LONDON, W.C.2 ; AND ASHFORD, KENT

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The headquarters of the Technical and Advisory Section are at Bradbourne, Larkfield, and visitors are asked to call there before going to the Station and not to proceed direct to the Laboratories at East Malling.

All *correspondence* should be addressed to East Malling Research Station, near Maidstone, Kent.

Visits may be paid on any weekday, *by appointment* if possible (Saturday afternoon under exceptional circumstances only).

Passenger Station : East Malling Halt (Southern Railway). *Goods Station :* Aylesford (Southern Railway).

Bus Services : From Maidstone by the Maidstone and District Motor Services Limited, every 20 minutes from Maidstone to Larkfield. From London the coaches call at East Malling and Larkfield on certain inward and outward journeys.

Visitors coming by road should take the turning to East Malling Village, opposite the Bull Hotel, Larkfield, on the main London-Maidstone Road. The entrance gate to Bradbourne is on the left approximately 100 yards down the road.

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EDITORIAL

THE Annual Report for 1941 has been arranged on the same lines as in the two preceding years when certain modifications were introduced in order to economize space and therefore paper.

Again the general reviews of the research work as set out in Section II are confined to the more important features of progress during the year, and only those summaries of papers published in other journals have been included which record important stages in our work.

In view of the fact that it is difficult to maintain that close contact with our Members which we do in normal times, we have added a new feature, a revised spray calendar. This brings to the notice of our Members the many improved recommendations since the 1934 Calendar was circulated.

The delay in the publication of this Report has again enabled us to give a more complete account of the farming year in Section I, and we have brought up to date all changes in Staff.

Mr. Bagenal has helped in assembling Section IV. The heads of Sections are responsible for the Sectional Reports, and the general editorship has again been undertaken by Dr. Wormald.

R. G. HATTON.

August 1942.

Section I

THE EXPERIMENTAL FARM

Contributions from J. AMOS, F. H. BEARD, R. G. HATTON, T. N. HOBLYN and H. B. S. MONTGOMERY

Although 1941 will be generally remembered as one of the poorer fruit seasons, it was not one of unrelieved gloom, the situation being to some extent retrieved by the performance of some of our standby varieties such as Worcester Pearmain apple, Czar and Giant Prune plums.

After two comparatively heavy crops of apples and pears in 1939 and 1940, a number of the most important varieties—especially Bramley's Seedling—definitely showed an "off year" tendency. Plums and cherries also had in 1940 the heaviest crops yet harvested. Added to this, the blossoming season of 1941—though comparatively late—was one of the most inclement in our records (see weather report, p. 35). After a warm spell in April, the winds were strong from the N.E. from 23rd April to 11th May, during which time many kinds of fruit completed their blossoming period. There was a notable absence of insect activity. In addition, there were three severe frosts recorded on the 4th, 11th and 16th of May, and numerous ground frosts. Finally weather conditions at blossoming time interfered with the normal spray programme, thus rendering the control of Apple Scab very difficult.

Experimental Orchards.—Top Fruits.—*Apples.*—The total crop of 50 acres was only 3,700 bushels, of which 1,545 were Worcester Pearmain. Over the previous 5-year period this variety, in our rootstock trial orchard, had averaged 3 bushels per tree annually, and even in this inclement year it yielded 1½ bushels per tree. The peculiarity of the season was that certain varieties not usually considered frost resistant—Beauty of Bath, Allington Pippin, Grenadier, and Miller's Seedling—came through the bad weather conditions fairly successfully. The cultural and environmental conditions appeared to have little in common. In this connection the comparative susceptibility to frost damage of blossoms in the green-bud, pink-bud, and fully open stages, as shown by recent research (see p. 29), may afford a partial explanation. The Grenadiers averaged 280 bushels per acre and Miller's Seedling 300. It is interesting to note that some Bramley's Seedling frameworked to Grenadiers in the spring of 1940, yielded a bushel per tree in 1941.

Pears.—The total yield was 490 bushels off 7 acres. Conference and Durondeau cropped the best, the former producing fruits which were largely seedless and often showed only rudimentary cores. Dr. West of the Ditton Laboratory has indicated that such pears appear to behave very differently in gas storage from normal ones. The Dr. Jules Guyot were definitely in an "off" year.

Plums.—The total yield was 2,000 halves off 11½ acres, of which 1,150 were Giant Prunes. This variety after producing an average of 6 halves per tree in 1940, averaged 2 halves per tree in 1941. Czar and Rivers' Early Prolific were the only other two to produce appreciable crops with the exception of Red Cherry Plum, which yielded 120 halves off comparatively few young trees in the more sheltered positions.

Following heavy crops in previous years, Warwickshire Drooper failed to blossom this season. Young trees of Victoria appeared to suffer from lack of pollination, since an early promise of a heavy set of fruit disappeared at the "June drop".

Cherries.—Kentish Red was the only variety to yield an appreciable crop (1¼ tons) per acre. An acre of Morellos gave only 26 halves. Several varieties of sweet cherries, Early Rivers in particular, had a large proportion of malformed blossoms, and many varieties were found later to be suffering severely from a bacterial trouble. The total crop off 6 acres was less than 100 halves.

Small Fruits.—*Strawberries.*—The 10 acres of M.35 Royal Sovereigns, which looked so vigorous and healthy the third year from planting, averaged only just over a ton per acre. The damaging frosts in early May killed approximately 30% of the blossoms in green bud, while a further 8% were destroyed between the 11th and 16th. All the big and early fruits were thus eliminated, while the remaining crop was further reduced by the drought which set in on 16th June and lasted till 12th July

Raspberries, Loganberries and Blackberries.—The yields of the former two were drastically reduced by the drought, as well as by frost damage in the case of raspberries. The Loganberries still showed the effects of the winter injury of January 1940. Blackberries (Himalaya) came through better and cropped at rather over 2 tons per acre.

Black Currants.—Black Currants suffered most of all from the cold winds and frosts, the best yielding being Baldwin with 8 cwt. per acre.

R.G.H., T.N.H. and J.A.

Experimental Nurseries.—The growing shortage of rootstocks has caused much concern amongst nurserymen and we have been encouraged to go forward again with the production of clonal rootstocks so as to maintain a nucleus for re-establishing commercial beds after the war. Ten acres of the Bradbourne land has been set aside for a new stoolbed. Three acres were planted in the spring of 1941 and two more a year later to replace older areas recently grubbed. The remaining five will, it is hoped, be planted with rootstocks in 1942-3, when the original three acres should yield a first crop of some 36,000 rootstocks. The older beds which still remain, mostly planted in 1927 on Newgates Field, will be temporarily retained, but, at fifteen years old, some sections are becoming uneconomical and these will be removed as the new area comes into production and the land used for food crops.

In place of the usual two or three acres of rootstocks planted for budding experimental material we set out somewhat less than one-quarter of an acre, and this, with the clearing of the older top fruit nurseries, has made it easier to undertake the re-selection and propagation of healthy bush fruits.

At the request of the Ministry of Agriculture we have arranged to increase materially our stocks of healthy small fruits within the next two years in an endeavour to meet the anticipated demand for nuclear stocks true to name. Some two acres of black currant cuttings were set out at the end of the year. The best of the new raspberries and our clonal loganberries are being multiplied as rapidly as possible.

Eight acres were occupied by strawberry runner beds, half of which were the recently selected Royal Sovereign M.40 and half M.35.

At the end of the year ten acres of M.40 were planted at the Research Station and a further eight acres in daughter nurseries under our control. These new areas should yield from half to one million healthy plants in 1942-3, mainly for the further propagation and establishment of healthy stocks.

R.J.G.

Hops.—The 9 acres of experimental Hop garden is undergoing considerable change. Only 4 acres are now devoted to the small (15-18 hill) plots of some 160 new seedlings which are being tested under the "five year" plan. Approximately half-acre plots of the most outstanding new varieties to date, including Brewer's Favourite, Quality Hop, Fillpocket, Brewer's Gold and Bullion Hop, have been or are being established, both with a view to producing a sufficient bulk of dried hops for brewing trials and also to afford a range of varieties of differing habits upon which to develop the cultural and training trials.

The weather in 1941 was not favourable to the growth of hops and favoured the spread of Downy Mildew. Fortunately better conditions prevailed in September and we were able to pick our entire crop in good condition. As might be expected yields of most varieties were lower than normal, though there were some outstanding exceptions. Bullion Hop (Q43) cropped at the rate of over 31¾ cwt. per acre, whilst Brewer's Gold (C9a) gave nearly 26¾ cwt. per acre. The crop of Bullion Hop was the heaviest so far recorded for this variety in our gardens. For the third season in succession, hops of the New Mexican type were adversely affected by seasonal conditions and the majority bore small, poorly ripened cones.

Picking and drying were made much easier by the reduction in the number of small plots of varieties of all seasons and types, though to some extent this was offset by the generally low yields. Picking was completed in 17 days and the total growth was just over 5 tons, though 2½ acres were quite young hops.

F.H.B.

Arable Crops.—It was possible to employ some 81 acres of ground, including Bradbourne Park, in the production of primary food crops.

Potatoes.—Sixteen acres of Arran Banner, from "once grown" seed, yielded 10 tons per acre. The season did not suit this variety on our soil and a high percentage of "hollow heart" tubers was produced and spoilt the sample.

Cereals.—After a very difficult harvest, 39 acres of Victor wheat averaged 5⅓ quarters per acre. Twelve acres of Plumage Archer barley gave nearly 6 quarters per acre. Six acres of spring sown Victory oats, on ground which had recently been cleared of rootstock stoolbeds, gave a poor return.

Peas.—Eight acres of canning peas, mostly grown between young fruit trees or upon recently grubbed fruit tree nursery ground, gave 5½ tons of dried peas.

R.G.H. and J.A.

Routine Spraying Programme.—The programme was based on the recommendations now embodied in the new edition of the Spray Calendar, which is being distributed with this report (see p. 68), and will therefore not be dealt with in detail here.

By making an early start with the winter washing the job was completed early in January, so that the unfavourable weather during the latter part of January caused no delays in the spraying. The apple trees in Kiln Field, which otherwise received no winter spray, were sprayed in mid-February with a

D.N.C. petroleum wash diluted to give 6% actual petroleum oil. Early in March, the rest of the apple plots were sprayed with petroleum oil emulsion (6% actual oil) against Capsid. Very little damage occurred as a result of this latter spraying, except in a few places where trees had been accidentally sprayed twice. This occurred especially where two "settings" of sprayers adjoined. Where the control of Capsid was not sufficient nicotine and soap was applied during pink-bud.

A full Scab spray-programme was carried out on pears, and consisted of two pre-blossom lime-sulphur (2½%) sprays followed by two post-blossom Bordeaux mixture (4-6-100) sprays. Good control of Caterpillar was achieved by the addition of 2 lb. lead arsenate powder to the green-bud spray.

On apples, the first pre-blossom spray (green-bud) was of lime-sulphur (2½%) with 2 lb. lead arsenate per 100 gallons. Owing to a fear of aggravating frost damage sustained in early May the pink-bud spray was omitted. Unfortunately wet weather delayed the application of the petal-fall spray so that Scab got a good grip on the trees and Sawfly was virtually unchecked. A portion of one plot was sprayed at pink-bud with 1% lime-sulphur and these trees bore twice the crop of comparable unsprayed trees thus showing that Scab-infection at blossoming time, resulting in a drop of affected fruitlets, was more serious than the combined effects of lime-sulphur and frost. Lime-sulphur at ¾% towards the end of June checked the spread of Scab to some extent, but the picked crop showed a high percentage of scabby fruit. Lead arsenate (2 lb. powder per 100 gallons) was applied in early July and effectively controlled Codling. On certain plots Apple Blossom Weevil was serious in spite of efforts to control it with Derris dust applied about green-bud stage.

Two sulphur dustings for Mildew were applied to all strawberry plots before fruit-picking time and the runner beds were dusted again in early September.

All young plums were sprayed with Bordeaux mixture (4-6-100) during the second week of June against Bacterial Leaf-Spot.

An attack of Capsid bug (*Lygus*) on blackberries was dealt with by nicotine and soap towards the end of June. There was no appreciable amount of Raspberry Beetle on the blackberries so they were not sprayed with Derris.

All young walnuts in the nursery were sprayed twice in the summer with Bordeaux mixture (6-9-100) against bacterial blight.

The hops were washed twice with nicotine and soap against aphis during June, and nicotine was also added to each of the copper (a Bordeaux substitute) sprayings against Downy Mildew. Two of these sprays were given to all the hops and a third towards the end of August to all but very forward varieties. Red Spider became important this year for the first time and was successfully controlled by lime-sulphur 1% on the 23rd July. A change of colour occurred where this spray fell on the copper spray that preceded it, but no damage resulted.

The cherry trees on the farm were greasebanded in the autumn, as Caterpillar had been gradually increasing from year to year on these trees, and this proved a completely satisfactory control measure. One plot of young cherries received a spray of Bordeaux mixture (10-15-100) towards the end of October to control bacterial canker. This spray treatment is now being adopted as a routine measure for all young cherry trees.

H.B.S.M.

Section II

GENERAL REVIEW OF RESEARCH WORK

WITH LISTS OF PAPERS PUBLISHED DURING THE YEAR

I. POMOLOGY

By R. G. HATTON and W. S. ROGERS

A.—Tree Fruits.—*Rootstocks.*—The 40 acres of field experiments comparing the effect of different rootstocks for apples, pears, plums and cherries have been maintained, with the minimum of records necessary to establish productiveness in relation to age, and length of life of various important stock-scion combinations. On the standardized plots of Cox's Orange Pippin and Worcester Pearmain planted on five Kent soil types, differences in rootstock influence are now seen to be clearly accentuated by the soils upon which the trees are growing. These observations will have great value in advising the best stock-scion combinations for different environmental conditions.

A selection was made from about 900 new apple rootstocks, bred for immunity to Woolly Aphis, using (i) tests for good nursery performance, and (ii) analysis of root anatomy by means of the percentage of bark in cross section of the root, which has been found in preliminary tests to be generally correlated with vigour and precocity. A complete range of vigour among rootstocks of good nursery behaviour was thus found, and 55 immune stocks, divided into 7 " vigour " groups, were chosen for further propagation and trial (E184). A paper was published (E174*) on the anatomical studies of stems and roots of hardy fruit trees which showed striking differences between different clonal rootstocks. The root anatomical work is being further developed in the direction of finding a method of identification of rootstocks from samples of root, and the effects of soil and scion differences in this connection are being studied.

A few pear and plum seedlings which have given evidence of being ready rooting in layer beds have been planted out for further propagation tests.

In the trial of Czar and Victoria plums on new clonal rootstocks small crops of Czar were harvested in 1940 and 1941. In both seasons the tendency of the trees to earlier cropping and dwarfed growth on St. Julien K and on Michaelmas Prune, previously shown in the nursery trial, was maintained. The trial of four gage plums, Cambridge Gage, Oullins Golden Gage, Denniston's Superb, and Early Transparent on six rootstocks has been planted out between established Giant Prunes which will be grubbed as need arises.

Among the quinces grown from seed obtained in Russia, it appears that some have a dwarfing influence, but are not incompatible. A preliminary trial of 15 selections has been started.

A small trial of double- and single-worked Williams' Bon Chrétien pear on quince has been interplanted between some bush apples, to follow up preliminary indications in the nursery, and a larger series has been placed on a commercial holding.

Propagation. A nucleus of rootstocks has been maintained ready for rapid multiplication when needed, and improved propagation methods are under investigation.

Re-working, Frameworking etc.—Experiments in the frameworking of mature apple and plum trees, initiated in 1938, have been reviewed and two papers prepared. For apples the method proved very flexible, good results being obtained from grafts made from February to June. Initially, the earlier grafted scions made most growth and the cleft-grafted scions were more vigorous than the bark grafted ones, but by the third season the trees had largely evened-up. During this period trees grafted with long scions gave more fruit than those with short. The influences of fifteen intermediates on the vigour of Cox's Orange Pippin scions varied little in the first four seasons, but there were more differences in blossom and fruit production.

In frameworking plums the condition of the scion wood proved very important. Precautions were also found to be necessary to prevent the entry of the Silver Leaf fungus into the wounds and to ensure against damage to the young growth by high winds. Losses from these causes somewhat clouded the issues under trial, but cleft-grafting was clearly shown to be superior to bark grafting. It was encouraging to find little evidence of incompatibility in sixty-nine combinations, although one intermediate and some of the scion varieties were known to be incompatible with certain rootstocks.

* Summary in *Rept. E. Malling Res. Sta. for 1940*, p. 19.

The experiment comparing three methods of topworking and one of frameworking of established Newton Wonder apples, which was begun in the spring of 1935, was analysed and prepared for publication. Many growers no longer want to grow Newton Wonder, but a great difficulty in overworking this variety is its susceptibility to Silver Leaf (*Stereum purpureum*) when re-worked. This varied according to the grafting method used, the worst was topworking by rind grafting, next came oblique cleft grafting. Where two large branches of Newton Wonder were left unworked for one year the loss by disease was reduced ; frameworked trees suffered less from disease than any of the topworked trees. The frameworked trees cropped heavily the third season and continued to bear more fruit in subsequent years than trees worked by any other method. At the end of seven seasons the frameworked trees had averaged nearly three times the crop of any of the others. The first fruits borne on frameworked trees were of better quality than those from topworked trees. The experiment has clearly demonstrated to growers that when reworking apple trees susceptible to Silver Leaf, it is important to retain as much of the head of the tree as possible and to avoid making large wounds ; frameworking fulfils these conditions well. It has also strikingly illustrated the economic value of rapid conversion by frameworking.

Manipulation of incompatible combinations.—Material has been planted to investigate further methods of bridging incompatible stock/scion combinations. In spite of the knowledge acquired about stock/scion relationships numerous trees, which are potentially incompatible at the graft union, have been planted commercially. A notable example is the pear Williams' Bon Chrétien worked direct on to most varieties of quince.

On the plot of Williams' Bon Chrétien trees double- and single-worked on quince already mentioned, the latter will be bridge-grafted and inarched in various ways with mutually compatible scions. From preliminary experiments it appears likely that at least one of these methods will prove efficacious and enable the grower to prevent the death of trees by some comparatively simple manipulation.

A growers' bulletin describing methods of grafting appears on p. 60.

Cover-cropping and grass orcharding.—Trials of a wide range of cover crops for the maintenance of soil organic matter in fruit plantations have given interesting and encouraging results. The scope of the programme, and cultural notes on promising cover crop plants, were given in a preliminary report (E181).

Indications of beneficial effects of some of the treatments began to show in 1941 on fruit colour, and on certain "deficiency" disorders such as interveinal and marginal leaf scorch. It is clear that valuable effects can be expected, with crops suited to the conditions. A risk of check to tree growth from certain treatments is suggested, however. Careful choice of plants, sowing time, and manurial treatment, appears very important. A study of water usage by the various cover crops is proving enlightening. While it is clear that any bulky cover crop will use much water, interesting differences are indicated. These may be connected with the root zone occupied by the plants, and further studies on this are in preparation. The harmful effect of winter washes on young seedling cover crops was more severe under the hard winter conditions of 1941-2 than in 1940-1.

Inorganic fertilizers.—The established trials of inorganic fertilizers were continued. In the test of residual effect of potash, mature Bramley's Seedling trees which had received one ton of sulphate of potash (1,086 lb. K_2O) per acre during the previous five years, showed no serious leaf scorch in 1941 after two years without any potash. In another trial a cover cropping treatment has been added. The effects of the fertilizers on the cover crops were very striking.

Soil Moisture and Irrigation.—Some further progress has been made in the simplification of use of soil moisture tensiometers, and about thirty instruments have been in operation on fallow soil and under various tree and cover crops. Preparations have been made for trying out a new electrical method of moisture determination, offering a higher range than the tensiometers. A short review on making the best use of water in food production has been published (P4), pointing out ways of conserving the natural water supply, and the conditions under which artificial irrigation is likely to be of value. (See also under Small Fruits.)

Pruning.—The series of dehorning experiments in connection with the non-setting of pear blossom (see below) was continued on Dr. Jules Guyot on clonal free-pear rootstocks. Set of fruit was poor, owing to weather conditions, but records on leaf size indicated that, while dehorning might increase leaf size on the cut branches themselves, the leaf size on lateral branches was not increased.

The trials of pruning treatments designed to combat biennial bearing have been continued, but frost damage to blossom clouded the results in 1941. One interesting feature that appeared was that while in other years severe spur thinning resulted in a greater percentage blossom set, in 1941 the reverse occurred, suggesting that the spur thinning induced greater susceptibility to frost damage.

Non-setting of Pear Blossom.—Two papers have been published on non-setting of pear blossom (E182 and 183).

Low temperature injury to blossoms.—Experiments were made in a temperature controlled chamber at the Ditton Laboratory to determine whether blossom trusses of Cox's Orange Pippin, whose spur leaves were damaged through adverse weather conditions at the time of spraying, were more susceptible to injury than those with undamaged leaves. This proved to be so, for 79 per cent. of the blossoms whose spur leaves were damaged were injured, as against only 45 per cent. of the blossoms whose spur leaves were undamaged.

Winter injury to fruit trees.—The investigation of injury by the severe winter conditions of 1939-40 has been written up. At East Malling the main damage was in bark splitting on the trunks of trees affected, mostly in apple. The varieties Cox's Orange Pippin, Duchess' Favourite, Allington Pippin, Beauty of Bath and Lane's Prince Albert were affected. Tacking down the edges of the uplifted bark and sealing the cracks with vaseline promoted more rapid and neater healing of the wounds. Careful arrangement of the nails was found important, to avoid the bark pulling away. Even the trees which were not nailed, however, had, up to autumn 1941, shown no bad effects in growth or cropping, in spite of the gaping wound in the trunk. Callus formed on the uplifted bark, and eventually new phloem and xylem. In some cases bark lifting occurred without splitting. Here healing was rapid. One-year-old wood and some buds were also affected in pears.

An enquiry among growers who had reported bark splitting revealed varying degrees of damage and of success from nailing. In several cases Silver Leaf infection and other severe damage to trees following the frost injury were reported. More severe damage, including killing of branches and whole trees, was found in other parts of Kent. In most cases the lowest areas were worst affected, probably by the very low temperatures reached on some calm nights. Thirty-four degrees of frost were recorded near one affected plantation. Bramley's Seedling trees, mostly over 40 years old, were the most severely damaged.

Varieties and classification.—Opportunity arose to add some fifty pear varieties to the cordon collection.

Breeding.—A preliminary rigid selection of new seedling rootstocks for pomological tests has been made as reported above. Eighteen seedling apples, selected as promising dessert sorts for early or late use, have been frameworked on to mature trees. The results of a genetical study of the inheritance of resistance and susceptibility to sulphur damage to foliage in apples has been published (E178).

Apple storage trials.—In collaboration with Dr. West, a series of experiments was started on Bramley's Seedling, Newton Wonder, and King Edward VII apples to test the effect of the " Ditton Apple Dip " on storage quality on a commercial scale. Apples were placed in common store, in cold store and in clamps in the open air. Whilst the trials confirmed that the period of maturity was delayed in the dipped fruits, it was clear that a number of other factors need investigation before the method can be generally recommended. (See VII. Insecticides and Fungicides.)

B.—Small Fruits.—**Classification, nomenclature and varieties.** A new variety trial of *raspberries,* including 12 new seedlings raised here has been started with Norfolk Giant and Baumforth B as controls. Of 1,000 further crosses 15 have been chosen for propagation on a scale which will make possible distribution to interested growers for trial in various districts. A preliminary distribution in small numbers of canes has shown that no one variety is the most suitable for all conditions. A further 100 selected seedlings are being propagated, for observation here. One factor needing consideration is that some varieties which appear promising at first may show a sudden degeneration in a few years.

The work of the past ten years on *blackberries, loganberries and other hybrid berries* has been reviewed and the results published in three papers (Esf 42*, 43* and 44). The first gives the salient botanical characters of the chief commercial varieties of cultivated blackberries, loganberries and other hybrid berries and the method of selection of parents and the establishment of clonal races of these varieties. The results of a survey of forty-eight commercial plantations in which blackberries and loganberries were grown were described, and differences in botanical characters and in cropping between loganberry variants obtained from some of these plantations and grown at the Station were noted. Comparative trials of (1) two forms of Parsley-leaved Berry and (2) Himalaya and Black Diamond were described. In the second paper is an account of a trial of Loganberry and Phenomenal Berry to study the comparative value for commercial purposes of different methods of training the cane and different spray treatments for the control of Cane Spot. A very good control of Cane Spot was given by a combination of the best training and spray treatments. (See VII. Insecticides and Fungicides). The third paper conveyed the practical points to fruitgrowers.

* The references to these two papers were given in *Rep. E. Malling Res. Sta. for 1940,* p. 20.

Enough clonal true loganberry plants have been raised for a trial of its potentialities on a commercial scale and 1¼ acres have been planted.

In *strawberries* progress has been made both with "susceptible" and "carrier" varieties. Although the crop was much reduced by frost, the good vigour and cropping of the new Royal Sovereign clones, selected from stocks collected in Co. Mayo, Eire, and found to be free both from Yellow-edge and Mild Crinkle viruses, justified the decision to send out the progeny of one clone for commercial propagation. This has been issued under the number Malling 40. A new variety trial, including Malling 40 with four other virus-free selections of Sovereign, also virus-free King George and virus-free Sir Joseph Paxton has been planted, with the original "Yellow-edge free" Royal Sovereign clone (Malling 35). The aphis control facilities provided by the new vaporized nicotine method make it possible to grow this carrier of mild Crinkle along with completely virus-free plants with every chance of success, and indeed, if perfect aphis control can be maintained, even severely affected carriers may be included with virus-free plants in future trials. As an extra precaution, however, both in trials and propagation beds, the three classes "susceptible", "intermediate", and "carrier" are still normally kept isolated from each other.

More attention has now been devoted to the so-called "carrier" varieties. It appears that at least a virus-free Huxley has been found; and of the small stock of plants received from the virus workers here, half have been sent to workers at Bangor, to divide the risk of infection or loss from other causes, and speed up propagation for pomological test. Another Huxley clone containing only mild Yellow-edge and showing good vigour and productiveness is being multiplied for further test. The virus-tested clones of Tardive de Leopold containing mild Crinkle only are undergoing preliminary pomological tests. Other varieties now ready for pomological test are Oberschlesien and Improved Paxton. A collection of many other potentially important varieties has been maintained, and a search is being continued, in collaboration with the pathologists, for stocks from which improved clones of known virus status can be raised.

A cropping trial of six selected varieties of *red currants* including Versailles, Laxton's No. 1, Fay's Prolific, Wilson's Long Bunch, Earliest of Fourland, and La Constante, has now replaced the old variety collection.

Propagation.—In view of evidence of deterioration of many commercial stocks, the propagation work of superior stocks of raspberries, black currants, loganberries, and strawberries has been greatly extended, at the special request of the Ministry of Agriculture. Ten acres of Malling 40 strawberry runners have been planted at the Research Station, and further areas on selected growers' farms will be supervised by the Research Station staff. Tip-layering, leaf-bud cuttings, and methods of propagation from suckers have been further studied for blackberries, loganberries, and other hybrid berries. A trial to compare the growth and cropping of plants raised by leaf-bud cuttings and tip-layering has been begun.

Breeding.—The field trials of new black currant seedlings are being continued and several are showing signs of being heavy croppers. Many strawberry seedlings fruited for the first time and several promising seedlings were selected as parents for further families. Many more raspberry seedlings show great promise, and are considered worthy of a more extended trial.

Cultural Measures.—Provision for superimposing at a future date a trial of organic and inorganic manures and of training methods upon the new planting of loganberries has been planned. Further records were obtained on the strawberry trials comparing effect of age of runner parent on performance of the progeny. The trial of burning of the straw litter gave a smaller crop where the straw was burnt than where it was not—a contrary result to previous trials—and a further repetition of the treatment has been made.

Irrigation and soil moisture.—Further irrigation trials were carried out with strawberries and raspberries. In the strawberry trial, ¾ inch of water, applied following 18 days drought, when the soil moisture tension was approaching 60 cm. Hg, increased the first grade fruit by 31 per cent., and the total marketable fruit by 19 per cent. Other moisture tensiometers have been used to help to forecast the best time for roguing strawberries for virus diseases, as symptom expression has been found to be related to soil moisture as well as to air temperature.

C.—Nuts.—A grove of walnuts of 19 varieties, selected from the large number collected and examined, has been planted out.

D.—Horticultural Meteorology.—The study of meteorological factors in relation to frost damage was continued under a special grant. During the first five months of 1941 the investigations carried out in the Vale of Evesham during 1940 were carried a stage further at East Malling. During this period simultaneous observations were made of temperatures on the hill and in the valley, together with wind speed and direction, amount of cloud, humidity, and visibility at dawn, in all kinds of weather. As these records were obtained during daylight the instruments were placed in Stevenson screens. The extensive records obtained have been statistically analysed and have thrown further

light on the conditions which determine the temperature difference between hill and valley. The importance of wind direction in relation to the slope of the hillside has been shown ; while the part played by the wind speed on the hilltop as well as that in the valley has been elucidated. There were indications that under certain conditions humidity might also be of importance.

Publications during the Year

In Relation to Tree Fruits.

The Inheritance of Susceptibility to Sulphur Damage in Families of Seedling Apples. H. M. Tydeman. J. Pomol., 1941, **19**, 137-45. (E178.)

Details of the reaction of seedlings from crosses between numerous apple varieties to spring applications of sulphur compounds for controlling Scab are given. Where the highly susceptible variety Stirling Castle was used as a parent, the proportion of sulphur shy seedlings was usually high, but it varied according to the other variety used as parent. Families in which White Transparent, Cox's Orange Pippin and Rote Sommer Apfel were used as one parent contained on the average from 7 per cent. to 54 per cent. of sulphur shy seedlings, but in the individual families great variation was found. With most of the other varieties used as parents, there was only a small proportion of sulphur shy seedlings in the families. It is concluded that sulphur shyness in apples is controlled in inheritance by genetic factors and that a number of genes are involved.

The Experimental Farm. Section I. J. Amos, F. H. Beard, R. G. Hatton, T. N. Hoblyn and H. B. S. Montgomery. Rep. E. Malling Res. Sta. for 1940 (1941), 11-14. (E179.)

General Review of Research Work, with lists of papers published during the year. Section II. Rep. E. Malling Res. Sta. for 1940 (1941), 15-31. (E180.)

Practical Notes on Cover Cropping of Orchards. W. S. Rogers. Rep. E. Malling Res. Sta. for 1940 (1941), 83-6. (E181.)

Studies in the Non-setting of Pears. IV. The Effects of Irrigation and Injection on the June Drop of Conference Pears. F. C. H. Gayner. Rep. E. Malling Res. Sta. for 1940 (1941), 36-41. (E182.)

Studies in the Non-setting of Pears. V. The Size of Flower on relation to its Position in the Truss. F. C. H. Gayner. Rep. E. Malling Res. Sta. for 1940 (1941), 41-3. (E183.)

Preliminary Selection of Apple Rootstocks immune from Woolly Aphis based on certain Anatomical Differences in Root Structure. A. B. Beakbane, E. C. Thompson and H. M. Tydeman. Rep. E. Malling Res. Sta. for 1940 (1941), 32-6. (E184.)

Making the Best Use of Water in Food Production. W. S. Rogers. J. Roy. Hort. Soc., 1941, **66**, 279-81, and Rep. E. Malling Res. Sta. for 1940 (1941), 82-3. (P4.)

Horticultural Meteorology.

Weather Conditions during 1940. H. C. Chapelow and H. M. Tydeman. Rep. E. Malling Res. Sta. for 1940 (1941), 44-5. (H40.)

In Relation to Small Fruits.

Some Practical Points in the Growing of Loganberries and Blackberries. A. B. Beakbane and N. B. Bagenal. Rep. E. Malling Res. Sta. for 1940 (1941), 89-91. (Esf44.)

II. STATISTICS AND RECORDS

By T. N. HOBLYN

Analysis of Data.—Summaries of records made in the field have been maintained and generally kept up-to-date. Several interesting problems have arisen in the statistical analysis of results examined. Thus, in some experiments measurements of two or more characters have had to be analysed together to elucidate treatment effects fully. Three examples, in each of which specialized statistical technique has had to be adopted, may be instanced. It has been found frequently in the past that one measurement seldom describes completely the "vigour" characteristics of differently treated plants. In strawberry plants both shape and vigour may be affected and it has been necessary to make a simultaneous analysis of their height and their spread to show the effects of different treatments. Again, in estimating the effects of cultural treatments on size of apples it is often necessary

to take both the size of the crop and the vigour of the trees into consideration. Another exceptionally interesting example occurred recently in the analysis of the effects of wind speed upon temperature differences between hill and valley. It was thought first that the valley wind speed alone mattered; but it was only when the hilltop windspeed was taken into account that the whole story was made clear, since both winds were highly correlated, but affected the temperature in opposite directions. (See I. Pomology D.)

Variation Studies. An account has been published of the studies in the variation of nursery fruit trees on vegetatively raised rootstocks (E177).

Sampling.—Close contact has been kept with other Sections in the simplification of recording technique to save time and labour. Sampling methods, ranging from estimates of potato blight to fruit colour and storage quality, have been evolved and visual estimates have had to replace more accurate measurements. In this, previous experience and prompt examination of such records have minimised the errors to which such methods are always liable. The importance of a close liaison between the Statistical Section and the observers in the field in this work cannot be too strongly emphasized.

Experimental Design.—Restrictions on planting new land have confined new field experiments to existing material and trees interplanted in established plantations. In the former, previous individual tree records have been invaluable in designing and interpreting the results of new trials; while in the latter, every effort has been made to anticipate and allow for sources of error incidental to experiments so planted. A field survey involving the sampling of numerous gardens, has been planned to discover the distribution and extent of mosaic disease in certain hop-growing areas. (See VIII. Hops.)

Publication during the Year

Studies in the Variation of Nursery Fruit Trees on Vegetatively raised rootstocks. Part I, II and III.
H. B. Cannon. J. Pomol., 1941, **19**, 2-33. (E177.)

Part I.

A study of the one-year growth of different varieties of apple and pear on a series of clonal rootstocks in four successive years showed that some varieties and rootstocks influenced variation more than others. Trees were more variable at the beginning of the growing season, owing to different times of bud-break, but levelled up after the growth peak. Pears were generally more variable than apples. Though the trees as a whole were more variable in two out of the four seasons, the experimental period was not long enough to reveal the particular set of weather conditions most favourable to good and even growth. Weekly measurements in one season, however, showed that temperature and sunshine were more clearly associated with growth increments than soil moisture. The more subject to good growth conditions the less variable were the young trees.

Part II.

The range in size and rooting of rootstock shoots on the stool was studied—the largest tending to be best rooted. Rootstocks bedded out for a year before replanting and budding became larger and better rooted than rootstocks taken straight from the stool, but they did not produce larger trees, since the latter rapidly caught up the former before the budding season. With apple trees there was little evidence that size, age or rooting of the rootstock had any influence on the growth of the maiden tree. Larger pear trees resulted from the use of larger and better rooted quince rootstocks.

Part III.

Budded apple trees proved superior to grafted trees in take, size and uniformity. They also tended to start growth and to level up earlier in the season. In the first few weeks of growth, grafted trees grew more rapidly, but reached their growth peak approximately a month later than budded trees. After this, however, growth fell off more rapidly. The source of the bud had no influence on the size of one-year-old apple trees. Pear buds from young parent trees made more growth than those from older trees. Larger pear trees resulted when the buds were taken from the apical end of the shoot, particularly when the shoots came from a young tree. There was no apparent difference between pear buds from shoots which had originated from the more shaded branches and those from the outside of the parent tree.

When the rootstock stem was cut back close above the union in the spring (low snagging), the resultant trees were larger than those on which a snag four inches long was left until late summer (high snagging). This effect was accentuated when the bud was on the shaded side of the stock.

Thus, unless all buds are inserted with exactly the same aspect, high snagging may lead to a greater variation in tree size.

There was no apparent advantage in removing the wood from the bud-shield before insertion. Although, when budding apples, the origin of the bud was of no importance, when grafting them, scions from the basal end of the shoot made more growth than those from the apical end. Stouter trees were obtained when side growths on grafted trees were allowed to make some growth and were pinched off at the fifth leaf. There appeared to be no advantage in grafting in such a way that the top bud of the scion was directly in line with the matched cambiums of scion and stock.

III. PLANT PHYSIOLOGY

By M. C. VYVYAN

Vegetative Propagation.—A report describing the rooting performance of a shy-rooting plum rootstock in the layer bed, and various experiments designed to improve the performance, is at the press.

Experiments on the best method for rooting hardwood cuttings of the plum rootstocks Myrobolan B are in progress. A preliminary trial, in a heated frame, with two growth substances, α-naphthalene acetic acid and β-indolbutyric acid, and two dormancy breakers, thiourea and sodium thiocyanate, indicated that the two growth substances were equally effective but sodium thiocyanate was superior to thiourea for this variety. A field experiment on a considerable scale, based on these results, has been planted out on two different soils. The relative effect of planting at once, or after an initial period of forcing in a heated frame, is being tried. The amount of natural hormone in stems and buds of various pear stocks is being examined by the coleoptile test.

A laboratory technique for the rapid determination, with a minimum amount of material, of natural rooting capacity of seedling pear rootstocks, and their response to various treatments, is being developed.

Experiments on the control of rotting in hardwood cuttings are giving hopeful results.

Physiological disorders of Rubi (in collaboration with Pathology). Further experiments were carried out on the causation of dwarf lateral scorch of raspberry and dieback of loganberry by mild winters, and their possible control. The results of the experiments have not yet been analysed, but the preliminary indications were that, though symptoms similar to those of dwarf lateral scorch could be induced by high temperatures during the winter, their control by a linseed oil emulsion spray was unpromising.

Diagnosis of Mineral Deficiencies (in collaboration with Biochemistry). The material collected in the autumn of 1940, with a view to finding the best method of sampling the foliage of apple trees for the diagnosis of mineral deficiencies, has now been analysed. The results show, amongst other things, that deficiencies of some elements are most marked in leaves from non-fruiting spurs. The investigation was extended in 1941, and nine series of samples were taken at various dates through the growing season with the same end in view, since it was to be expected that the best type of leaf sample would vary with the time of year.

Reduction of pre-harvest Fruit Drop.—The results of the 1940 experiments have been published (F35). These showed that sprays containing $2\frac{1}{2}$ or 5 parts per million of α-naphthalene acetic acid may reduce significantly the drop of fruit, during the last few weeks before picking, in the three apple varieties examined, Cox's Orange Pippin, Worcester Pearmain and Beauty of Bath. Laboratory experiments with the coleoptile test indicated that the activity of this growth substance is not reduced when the substance is mixed with lime-sulphur or Bordeaux mixture sprays. Field trials will therefore be carried out to find out if the leaf fall and fruit drop, sometimes caused by these sprays, can be reduced by the addition of this growth substance to the sprays.

In 1941 sprays containing this growth substance at concentrations of 5 and 10 p.p.m. were applied, a few weeks before normal picking time, to trees of the apple variety, Miller's Seedling, and here again a significant reduction in drop was obtained. Apples from these sprayed trees have been sent to the Chester Beatty Institute where tests are being carried out to make sure that fruit so treated is harmless when consumed. It is proposed to extend these spray experiments to other kinds of fruit such as pears.

Publication during the Year

Reduction of the Pre-Harvest Drop in Apples by Spraying with a Growth Substance. M. C. Vyvyan. Rep. E. Malling Res. Sta. for 1940 (1941), 46-9. (F35.)

IV. BIOCHEMISTRY

By W. A. ROACH and B. D. BOLAS

The Section has concentrated mainly on applying plant injection and plant analysis methods, already developed here, to practical problems in commercial plantations as described to fruitgrowers (K37). The simplest and best tried remedial measures have been used, but large-scale tree injection has been found necessary in special cases. Mr. B. S. Furneaux and Dr. N. H. Pizer of the South-Eastern Agricultural College, Wye, and Messrs. W. G. Kent, C. R. Thompson and J. B. Duggan, Advisory Officers in Commercial Fruit Growing to the Kent County Council, have co-operated in this work. Papers are in preparation on the cure of a whole plantation of apples of iron deficiency, and of cherry trees (so far on a small scale) of manganese deficiency. In both cases full crops have been produced on previously worthless trees.

The same methods have been used to give a " running commentary " on a number of the Station's experimental plots (see I. Pomology, A). Dr. D. W. Goodall of the Research Institute of Plant Physiology has co-operated in this and in the developments in methods found necessary. (See also III. Physiology).

There has also been co-operation with other sections in applying these methods to other problems of mutual interest such as certain diseases of plum trees and hops.

Although no fresh work has been done directly on the rootstock problem, light is being thrown on it by the general results obtained.

A scheme to test the practical value and limitations of these methods on a wide range of plants in various parts of the country has been planned and initiated in conjunction with the Research Institute of Plant Physiology.

Plant Injection.—Beneficial responses, have again been obtained in diagnostic tests, to the injection of compounds of some ten elements into a wide range of fruit, horticultural and other field crops. In all probability, therefore, the methods are applicable to most plants of economic importance.

Definite and differential responses to leaf stalk injections of nitrogen, phosphorus, magnesium, zinc, iron and boron were obtained in Comice pear trees of moderate and poor performance, and the results published (K38).

As a result of facts mentioned in the last report an experiment to determine how far making good a zinc deficiency lessens susceptibility to Apple Scab was inaugurated. (See VII. Insecticides and Fungicides.)

Work has been continued with promising results on the control of Silver Leaf in plums by the injection of disinfectants.

Continued improvements and simplifications have been made in injection apparatus and methods.

Plant Analysis.—Work has been continued on the improvement of methods both for diagnosing deficiencies by the mere inspection of spectrograms and for quantitative analysis.

Line densities are measured with a photometer. Reliable figures can be obtained for lithium, sodium, potassium, rubidium, caesium, silver, copper, and probably manganese. The interference of other elements such as phosphorus and silicon is being studied.

Work has been resumed on the spark method already partially developed here. This will be necessary for elements such as boron, titanium, vanadium, aluminium, phosphorus and silicon and desirable as a check on other methods for certain other elements.

Work has also been resumed on the polarograph, in the first instance, for zinc and later for other elements.

Work on the nature of resistance of plants to disease has been resumed in co-operation with Prof. Harington and his co-workers and with other sections here. (See V. Plant Pathology.)

Publications during the Year

Feeding the Fruit Tree—New Light on an old subject. N. B. Bagenal. Rep. E. Malling Res. Sta. for 1940 (1941), 87-88. (K37.)

Studies in the Non-Setting of Pears. VI. The Injection of Pear Trees for the Diagnosis of Carbohydrate and Mineral Deficiencies. F. C. H. Gayner. Rep. E. Malling Res. Sta. for 1940 (1941), 50-55. (K38.)

V. PLANT PATHOLOGY, MYCOLOGY AND BACTERIOLOGY

By R. V. HARRIS and H. WORMALD

A.—Diseases of Tree Fruits.—*Bacteriosis of Plum and Cherry Trees.*—Records taken during 1941 on the experiment in the control of the disease by the incorporation of "resistant stem-builders" indicated that such resistance may break down in certain graft combinations with susceptible varieties. A trial was started in collaboration with the Biochemistry Section, and University College Hospital Medical School (Professor Harington), to attempt to find the cause of varietal and seasonal resistance to this disease.

Experiments in the control of bacteriosis by spraying are reported under Section VII.

Blossom Blight of Pear Trees.—Inoculations with isolates from pear flowers confirmed the results obtained in 1940. An investigation of the relation between the weather conditions and outbreak of the disease, and of methods of control, was started. A preliminary report was published (C168).

Wilting of Plum Shoots in Layer Rows.—The fungus cause of this disease was determined by inoculation experiments, and preliminary field experiments in control by spraying gave promising results.

B.—Diseases of Soft Fruits.—*Virus Diseases of Cultivated Rubi.*—The preliminary routine testing of seven new seedling varieties of raspberry for their reaction to mosaic viruses, started in 1940, was completed in 1941.

Wildings and seed from an isolated locality in North Wales were collected for testing as possible supplementary indicators of mosaic viruses.

The reaction of the true loganberry to "dwarf" was determined by artificial transmissions. (See also VI, B.)

Virus Diseases of Strawberry.—Two papers dealing with the work on these diseases up to and including 1941 have been prepared for publication; they deal with (i) experiments, started in 1927 and recently completed, to determine the environmental causes of the fluctuation in the symptom expression of Yellow-edge in field plantations of Royal Sovereign; and (ii) the use of *Fragaria vesca* L. as an indicator for testing samples of strawberry plants for their virus content.

Further routine tests of commercial samples of plants for virus content and reaction were made, and in the gauze propagation house "nucleus" stocks were raised of selections of a number of varieties which have been passed forward for propagation and pomological testing. (See I. Pomology.)

An experiment was made to determine whether yellow-edge and crinkle viruses in the Royal Sovereign variety are seed transmitted.

A study was started of the apparent breakdown of certain stocks of the "carrier variety", Huxley's Giant.

Strawberry Leaf Blotch.—A fungus disease of strawberry plants not previously recorded in Britain was found in Kent. A short description was published (C171), and a further account appears on p. 44 of this report.

C.—Diseases of Hops. See Section VIII.

D.—Miscellaneous Investigations.—*Grey Mould.*—Results of observations in 1940 have been published (C167 and C172). In 1941 a number of species of weeds in one hop garden and in certain fruit plantations were found to be infected with Grey Mould. The importance of these hosts as sources of the infection of crop plants has yet to be determined.

Publications during the Year

Notes on Plant Diseases in 1940. H. Wormald. Rep. E. Malling Res. Sta. for 1940 (1941), 55-8. (C166.)

The Grey Mould of Fruit and Hops. Some Possible Sources of Infection. H. Wormald. Rep. E. Malling Res. Sta. for 1940 (1941), 59-61. (C167.)

Bacterial Blossom Blight of Pear Trees. H. Wormald and H. B. S. Montgomery. Rep. E. Malling Res. Sta. for 1940 (1941), 58-9. (C168.)

Recent Research on Diseases of Fruit Trees and Bushes in Britain. Presidential Address. H. Wormald. Trans. Brit. mycol. Soc., 1941, **25**, 4-25 (C170.)

This address, delivered at the Annual Meeting of the British Mycological Society on December 14th, 1940, summarizes the results of research work carried out in Britain on diseases of fruit trees and bushes during the last twenty-five years.

Leaf Blotch of Strawberries. H. WORMALD and H. B. S. MONTGOMERY. Gdnrs' Chron., 1941, **110**, 180. (C171.)

A Leaf Blotch of the Strawberry bearing fructifications of *Phyllosticta grandimaculans* was observed by C. J. Hickman at Westerham, Kent, in 1939, and by the writers in several other localities in Kent in 1941.

Grey Mould of Fruit, and some of its Host Plants. H. WORMALD. Gdnrs' Chron., 1941, **109**, 44. (C172).

An eye rot of Apples is associated with the presence of Grey Mould (*Botrytis cinerea*) on the calyx lobes. The occurrence of Botrytis on the Dandelion, Black Bryony, Bramble and Sweet Chestnut (cupules) is described. Strains isolated from these hosts were found by experiments to be able to infect Apples.

VI. ENTOMOLOGY

By A. M. MASSEE and R. M. GREENSLADE

A.—Tree Fruits.

Apple Blossom Weevil.—Three control methods have been investigated :

(*a*) Repellants. Fourteen substances have been tested in the laboratory, and four were selected for a field trial, one of which slightly reduced infestation by keeping the weevils away from the flower buds during the egg-laying season.

(*b*) Atomized spraying reduced the infestation slightly, but owing to unsuitable weather conditions could not be applied until most of the eggs were already laid.

(*c*) The use of trap bands treated with substances, mainly essential oils, to attract the weevils and so increase the catch. None of the substances was more attractive than untreated corrugated cardboard. Sacking was twice as effective as cardboard, and bands made of moss were not successful.

Other Species of Leaf Weevils.—A paper (D157) describing and sorting out the various species occurring on fruit was published.

Fruit Aphides.—The pear " blue bug " was shown to consist of three species. Their different life histories were followed throughout the year.

B.—Small Fruits.

Vaporized Nicotine Treatment for Strawberry Aphis.—Most of the strawberry plots at the Research Station were fumigated in July, 1941, by Pest Control Ltd., and the effect of this on the aphis population was studied. A paper (D163) on the control of strawberry aphis by vaporized nicotine was published.

Strawberry Aphis Survey.—Regular population samples from all plots have revealed a sudden wide diffusion of the aphis throughout each plot in June, although there was no mass flight of aphides. This could not have been seen by casual observation and emphasizes the value of regular sampling. Two papers (D158 and 160) describing the details of migration under Kent conditions were published.

Economic Vectors of Rubi Diseases.—Alate viviparous forms of two species of aphides have been used in a further attempt to transmit raspberry mosaic. A paper (D156) was published dealing with the species of aphides and leaf hoppers on Rubi and their possible association with virus disease.

Two species of aphides have been tested in an attempt to find the vector of " Dwarf " of certain kinds of Rubi. " Dwarf " symptoms appeared, in the spring of 1941, on three plants colonized by viruliferous aphides in 1940.

Reversion of Black Currant.—The aphides associated with black currant have been tested as likely vectors of reversion.

Control of Tarsonemid Mite.—Fumigation with methyl bromide as an alternative to the warm water treatment has been tested.

Economic Vectors of Strawberry Diseases.—Experiments show that the alate viviparous female stage of the strawberry aphis is a vector of Crinkle virus.

Black Currant Leaf-curling Midge.—Further observations on life history were carried on, and a preliminary paper (D161) published.

PUBLICATIONS DURING THE YEAR

The British Brown and Green Leaf Weevils associated with cultivated Fruit trees and bushes. A. M. MASSEE. J. Pomol., 1941, **19**, 78-81. (D157.)

A short account is given of the five species of leaf eating weevils (*Phyllobius*) associated with cultivated fruit trees in Britain, viz. *P. oblongus* L., *pyri* L., *calcaratus* F., *argentatus* L., and *maculicornis* Gm. *P. pomonae* Ol., found on oak, and *Polydrosus cervinus* L., which very occasionally feeds

on wild crab apple leaves, are also alluded to. A key for the identification of the species that attack fruit tree leaves is supplied.

The Migration of the Strawberry Aphis Capitophorus fragariae Theob. R. M. GREENSLADE. J. Pomol., 1941, **19**, 87-106. (D158.)

The life history and economic importance of the Strawberry Aphis, *Capitophorus fragariae* Theob., are briefly discussed and the main part of the paper deals with the behaviour of the winged generations. In nature, the aphis is practically confined to the cultivated strawberry plant. Winged generations occur, but they serve merely to spread the species. There is no migration to an alternate host. (This aphis, however, has been found very rarely on *Potentilla anserina*.) The winged generations are economically important because they spread strawberry virus diseases from field to field. The spring alate aphides are adult for a short period in May or June and often occur in very large numbers. Their occurrence is not correlated with the flowering period of the plant. The autumn alatae, on the other hand, are less numerous and occur over a longer period.

The activity of winged aphides is known to be influenced by temperature and humidity, and evidence was obtained of the influence of light. Charts showing the temperature, relative humidity and wind speed prevailing during the time of production of the winged generations are reproduced and show that extensive migration is likely to occur only during comparatively short periods. They also show that extended migration of the autumn winged aphides is unusual but can sometimes occur, and that the transmission of virus disease at that season is therefore possible.

Migrating strawberry aphides are able to find single strawberry plants among other crops or among thick grass. They fly in all directions and cannot be much affected by the direction of the wind since they do not fly unless the wind speed is very low. Plants become infested at distances of at least 400 yards from infested plots of strawberries, and there is little doubt the aphides can migrate farther than this.

Wild strawberry plants growing under natural conditions do not become colonized by strawberry aphis, although cultivated plants growing under exactly similar conditions readily become infested. Under certain unnatural conditions wild strawberry plants may support large colonies of the aphis. The possible reasons for this are discussed and experiments are described which suggest that a sense of smell is not concerned with the choice of a host plant by this aphis.

Notes on Some Interesting Insects Observed in 1940. A. M. MASSEE. Rep. E. Malling Res. Sta. for 1940 (1941), 61-5. (D159.)

Strawberry Aphis and the Weather in 1940. R. M. GREENSLADE. Rep. E. Malling Res. Sta. for 1940 (1941), 65-6. (D160.)

The Black Currant Leaf Midge, Dasyneura tetensi (Rubs.). R. M. GREENSLADE. Rep. E. Malling Res. Sta. for 1940 (1941), 66-71. (D161.)

Work at East Malling on the Control of the Strawberry Aphis. A. M. MASSEE and R. M. GREENSLADE. Rep. E. Malling Res. Sta. for 1940 (1941), 92-4. (D163.)

The Hemiptera-Homoptera (Auchenorhyncha) associated with Cultivated Fruits. A. M. MASSEE. J. Soc. Brit. Ent., 1941, **2**, 99-109. (D164.)

Brief notes are given for the forty species of leaf hoppers observed to breed on, or to be associated with, cultivated fruits. The species are arranged under host plants, and more detailed notes are given of the economic species.

VII. INSECTICIDES AND FUNGICIDES

By H. B. S. MONTGOMERY, M. H. MOORE, H. SHAW and W. STEER

Laboratory Investigations.—Ovicides.—3 : 5-Dinitro-*o*-cresol showed the same toxicity to *Aphis pomi* eggs whether the spindle-oil emulsion containing it was alkaline or not. Some evidence was obtained that the toxicity of the oil itself, normally low to aphis eggs, increases with a decrease in the stability of the emulsion. This is being investigated more fully. Of other dinitrophenyl derivatives tested in sulphite lye-oil emulsion, 2 : 4-dinitro-6-cyclohexylphenol and 2 : 4-dinitrophenylethanolamine proved almost as toxic as 3 : 5-dinitro-*o*-cresol ; 2 : 4-dinitro-4′-hydroxydiphenylamine was somewhat less toxic, but may repay further study, whilst 2 : 4-dinitroaniline, 2 : 4-dinitrophenylcyclohexylamine, 2 : 4-dinitrophenylhydrazine, and 3 : 5-dinitrosalicylic acid showed little promise.

Further work in collaboration with the Department of Entomology, Imperial College of Science, showed that the oxygen uptake of Vapourer Moth eggs treated with fatal doses of nicotine was about normal and that the embryos (like those of *Aphis pomi*) developed, even though they failed to hatch.

After treatment with a petroleum emulsion, however, oxygen uptake was depressed or inhibited and the embryos failed to develop. A report on this work is in preparation.

Fungicides.—In the course of testing synthetic organic and organo-mercurial fungicides the need for certain refinements of technique arose. Working out these modifications required a large proportion of the total time devoted to fungicide testing. Several of the organic sulphur compounds tested showed a notable degree of toxicity, but none was of the same order as tetramethylthiuram disulphide. Phenyl mercury chloride was the most toxic of a group of highly toxic organo-mercurials and was selected for field trials on potatoes and apples.

Bactericides.—The survey of metallic salts was extended by testing and comparing the metals on a molar and on a valency basis as well as on the per cent. concentration of metal basis previously used. No evident periodic arrangement was noticed, but mercury, silver, gold, uranium, and copper were the most toxic. A report on this work has been submitted for publication. The method of testing used so far is not sufficiently discriminating for the further work contemplated and more sensitive methods are being worked out.

Field Investigations.—Insecticide Trials.—The experience gained in laboratory and field trials of the 3 : 5-dinitrocresol-petroleum oil wash has been summarized in a report (Q25). A further trial has been laid down to confirm the efficacy of the lower concentration of dinitrocresol previously used. In addition, the possibility of applying this type of wash early in the dormant season is being examined with a view to extending its season of use.

Fungicide Trials.—*Apple.*—In a new trial on young Cox's Orange Pippin apple trees, comparison was made of the fungicidal value of (*a*) combined sulphur in lime-sulphur with (*b*) elementary sulphur in various commercial preparations and with (*c*) mixtures of some of these with lime-sulphur, all materials being diluted to contain total sulphur equivalent to that of polysulphide in 1 per cent. lime-sulphur. The basis of comparison was the control of Apple Scab on foliage, frost having ruined the crop. In addition 0·1 per cent. of tetramethylthiuram disulphide was tested as a commercial preparation, and as the pure substance with sulphite lye or with glue as sticker. Lime-sulphur and the commercial preparation of tetramethylthiuram disulphide proved to be the two most effective of all these. The efficacy of elementary sulphur in the different preparations was not uniform, and in one to which a spreader was added was not thereby enhanced. A small ancillary trial of phenyl mercury chloride showed this material to be very highly fungicidal. All sprays proved safe, with the possible exception of the last-named.

In a spraying trial on commercial lines, lime-sulphur gave much better control of foliage Scab on Cox's Orange Pippin than a wettable sulphur preparation. Scab on the fruit of these Cox's Orange Pippin and of interplanted Worcester Pearmain, however, was equally well controlled by either spray ; Cox's was the more heavily infected. There were, on the whole, heavier crops from trees sprayed with wettable sulphur. Two pre- and three post-blossom applications of each spray were made, and the proportion of elementary sulphur in the wettable to polysulphide in the lime-sulphur was approximately 10 : 7 for the five sprays together. The discrepancy shown between results on foliage and fruit was probably initiated at petal-fall, when frequent rain hampered spraying operations ; the trial will be repeated.

Potato.—On the evidence of laboratory tests, phenyl mercury chloride was selected for comparison with Bordeaux mixture in a field trial against Blight on potatoes. The result was inconclusive for while the mercurial did not protect the foliage so well as did Bordeaux, there was so little Blight in the tubers that no differentiation was possible.

Spray Damage Investigations.—The results of two season's trials and of several season's field observations on the effects of winter petroleum spraying have been reported (Q26). It was found that an unduly heavy oil deposit, such as readily accrues from spraying in windy weather, is more important than the period of application as a factor in spray damage.

Further evidence was obtained from field trials that the damage frequently associated with the use of calcium arsenate on apples results from inherent properties of the material and not, to any substantial extent, from the method of compounding.

Some reduction of fruit set in Worcester Pearmain was recorded following an application to individual, fully-open flowers of 1 per cent. lime-sulphur. The spray was directed from a syringe-type hand sprayer into blossoms not visibly damaged by frost. The spraying of whole trees hitherto undertaken was abandoned on account of widespread frost damage to blossoms.

Biology and Control of Specific Pests and Diseases.—*Red Spider.*—In contrast with the two preceding seasons very little evidence of air-borne migration was obtained in 1941, which was not a Red Spider year.

Apple Capsid.—The relation between the date of spraying and the toxicity of petroleum emulsion is being further studied. (See Insecticide Trials, above.)

Apple and Pear Aphides. (See VI. Entomology.)

Bacteriosis in Plums.—There is as yet no further evidence of the effect of Bordeaux spraying on the incidence of stem cankers in Victoria. Leaf spot was again controlled by Bordeaux, applied on 12th June, and by colloidal copper applied on 27th June to similar, adjacent trees in another experiment ; there was no evidence that a budburst spray applied on 8th April was effective. Neither June spray left an unsightly deposit on the fruit, but each, and especially the later one, caused considerable leaf drop. In spite of this, unsprayed control trees were defoliated first in autumn. Many branch cankers, apparently a new phase of the disease, were first seen in July. The Bordeaux spray in June gave very good control ; any effect of the colloidal copper was masked by other treatments.

Apple Scab.—Allington Pippin was much more susceptible than Worcester Pearmain ; Newton Wonder and Cox's Orange Pippin were intermediate, and the infection on all these varieties was much heavier than in 1940. All trees were fungicidally unsprayed. Frost greatly reduced the crop. The analysis of records of disease intensity in relation to differential manuring is not yet completed.

The influence of zinc on the incidence of Scab in established trees of Cox's Orange Pippin is being studied by injection and by spraying. (See IV. Biochemistry.) A zinc-lime "Bordeaux", though practically non-fungicidal to *Venturia inaequalis* conidia in laboratory tests, is able to limit Scab infection in the field, possibly through acting as a nutrient. There was less Scab in 1941 on the foliage of trees sprayed post-blossom with a zinc-lime "Bordeaux" than on unsprayed trees ; infection was progressing before treatment began. Sprayed trees retained their foliage in autumn for a slightly longer period than unsprayed ones. Branches injected with zinc sulphate early in July showed a slight, though promising, reduction in foliage Scab on unsprayed, but not on zinc-sprayed trees.

Apple Scab in Storage.—Two preliminary experiments were made of incorporating a fungicide in an emulsion of arachis oil into which apples can be dipped to prolong their storage life. One experiment, on Bramley's Seedling, was made under controlled conditions, the fruit being sprayed with a suspension of conidia of *Venturia inaequalis* and allowed to dry before being dipped and then stored in a constant temperature cold chamber ; the other, on Newton Wonder, was made under commercial conditions, the fruit, not sprayed with spore-suspension, being clamped in the open after dipping. A commercial preparation of colloidal sulphur and one of tetramethylthiuram disulphide, each at 0·5 per cent. were tested. On Bramley's the fungicides gave no control of either storage Scab or fruit rots ; on Newton, where only colloidal sulphur was tested, no storage Scab developed and the fungicide gave no control of fruit rots. If the experiment is repeated the fungicides will be tested at much higher concentrations. Dipped fruits, irrespective of the presence or absence of fungicides, showed less storage Scab and less rotting than undipped. (See I. Pomology.)

Apple Bud Rot.—Few infections were present in spring, 1941, on Grenadier trees sprayed with Bordeaux mixture in October, 1940. Similar, unsprayed trees were also lightly infected. The spraying trial was therefore inconclusive and has been repeated.

Branch Blister Disease.—Very marked differences were observed in the susceptibility of many different varieties of pears on Quince C rootstock in the nursery. No consistent correlation was found between the presence of blister and the strength of the graft union.

Loganberry Cane Spot.—In 1940, infection was reduced by Bordeaux mixture applied at the end of August, 1939 (post-cropping) or in May, 1940 (pre-blossom). No improvement was obtained where an application of colloidal copper in June (Raspberry Beetle stage) was added to that of Bordeaux in May. In 1941, the May and June sprays together gave the best control, the May spray alone next, and the August (1940) spray least—and that only where the new cane was trained above the old. In each year there was more infection on the east of plants than on the west, the rows running north and south, and, in 1941, more where the young cane was trained beneath the old if the spray treatment was inadequate. (See I. Pomology.)

Apple Canker.—The results of the spraying trial are not yet available ; the trial is being continued.

Publications during the Year

Dinitrocresol and other Dual Purpose Winter Washes. H. Shaw and W. Steer. Rep. E. Malling Res. Sta. for 1940 (1941), 72-5. (Q25.)

Spray Damage and Apple Capsid Control by Winter Petroleum. W. Steer and M. H. Moore. Rep. E. Malling Res. Sta. for 1940 (1941), 76-81. (Q26.)

Winter Washing. W. Steer. Market Grower and Salesman, 1941, **19**, No. 12, 4-5 and No. 13, 4-5. (Q27.)

This is an account of the use of tar oil, petroleum oil and D.N.C. washes—when and how to apply them.

Winter Hygiene in the Fruit Garden. W. Steer. Gardening Illustrated, 1941, **63**, 625. (Q28.)

The use of the several types of winter wash (tar, petroleum and D.N.C.) on a garden scale is described.

VIII. HOPS

A.—Varieties and Cultivation Trials.

By F. H. BEARD

Commercial Varieties.—Further progress has been made with the clonal propagation of healthy stocks of Goldings and Fuggle. Material should be available next autumn for the planting of a cropping trial with Golding varieties and for an extensive propagation plot of the best stock of Fuggle.

New Varieties.—The crop from about 90 varieties was dried separately in order that the yield per acre and the number of bushels of green hops required to yield a cwt. of dried hops could be estimated. Samples of dried hops of 52 varieties were saved for subsequent resin analysis. The crops from 33 varieties were pressed separately in part pockets for use in brewing trials or for examination by an expert in the trade. Owing to war conditions only a few varieties of the 1940 crop were analysed and these were almost entirely ones which had given good analyses in past seasons. The analyses showed that these varieties maintained their position and that the season favoured a good resin content, though not so high as in 1939. Nonsuch Hop (OB53) and OM26 were again the richest varieties with a P.V. of 13·38 and 13·69 respectively. There is an indication that close planting may increase the cropping of these varieties sufficiently to make their growth a commercial proposition. The above results (for 1940 crop) were published by Professor E. S. Salmon of South-Eastern Agricultural College, Wye (B37).

Cultural Trials.—The existing trials have been continued and fresh plantings made for future work. With both Brewer's Favourite (OP21) and with Quality Hop (OO63) " pulling " reduced the crop. This is the first season in which " pulling " has affected the cropping of the latter. The new plantings afforded an opportunity for a comparison between rooted sets and strap cuts. The results were overwhelmingly in favour of the former. This comparison is being repeated. At the very wide spacing of 9 ft. apart in the rows the variety OI47 gave yields equal to that at 6 ft. apart. So far the cutting of the bine just below the breast wire (necessary for machine picking) has not resulted in any reduction of cropping of Fillpocket (Z62).

Manurial Trials.—High nitrogen (219 lb. N. per acre) gave an increase in yield of nearly 3½ cwt. per acre over low nitrogen (73 lb. N. per acre) with the variety OI47.

B.—Diseases of Hops.

By W. G. KEYWORTH

Verticillium Wilt.—Nine new outbreaks were reported during the season. On farms where control measures had been applied in 1940, several small outbreaks appeared to have been eradicated and others greatly checked by careful plant hygiene followed by the removal of infected soil and disinfection of the area with 2 per cent. formalin (eight gallons per square yard).

Resistance trials of Wye seedling varieties were continued but no variety showed outstanding resistance. Two other varieties grown on one farm remained healthy although adjacent to bad wilt areas and they were specially propagated for further trials.

A " fallowing " trial was started by planting young hops in a wilt area of ¾ acre which had contained 50 per cent. of wilted plants in 1938 and had not grown hops since then (i.e. for 2½ years). Only 2 per cent. of the young plants showed wilt symptoms in 1941 and this result is being followed up to try and reclaim large wilt areas by " fallowing " followed by soil disinfection.

Virus Diseases.—The results of inarching experiments to test for the transmission of Nettlehead became noticeable in 1941. Of 71 plants that had been inarched to diseased plants 85 per cent. showed infection, while 98 control plants grown adjacent to the indicators showed only 8 per cent. infected. It is concluded therefore that Nettlehead is transmissible by inarching and is probably a virus disease. The experiments have also shown that Nettlehead can be transmitted from plants in which the symptoms are masked by high temperatures. The results of manurial treatments on Nettlehead have so far been negative. Experiments started in 1941 have the object of determining whether Nettlehead can be transmitted by mechanical means and ascertaining the time of year when natural transmission is greatest. Six Fuggle plants from apparently healthy gardens have been grown in isolation and inarched to Golding indicators ; at least four of them proved to be Mosaic carriers and thus unsuitable for planting near Goldings. Nettlehead infected plants have been inarched to Fuggles, known to be Mosaic carriers, to determine the susceptibility of the latter to Nettlehead. Further mapping work has been done in Nettlehead-infected gardens to obtain information on the

spread of the disease. Symptom-masking has again been observed during the hot period of June to August.

(See Notes on Hop Diseases during 1941, pp. 42-43.)

C.—Insect Pests of Hops.

By A. M. MASSEE

Economic Vectors of Hop Virus Diseases. –Study of insect fauna to find insect vectors of Mosaic and Nettlehead. Tests made with immature, adult and winged forms of Hop-Damson aphis. Variation of fauna in widely separated hop gardens.

Hop Strig Maggot.—Study of life history and control measures in the field.

Hop Frog Hopper.—Study of life history and preliminary control measures.

PUBLICATIONS DURING THE YEAR

Twenty-fourth Report on the Trial of New Varieties of Hops 1940. E. S. SALMON. August, 1941. (B37.)

Of the 97 varieties (New and Commercial) tested, six New Varieties cropped at the rate of 25 cwt. or over to the acre, and fifteen at 20 cwt. or over. Owing to the effect of the dry season, particularly in August, on the " hot " soil at East Malling, several of the " New-Mexican " hybrids and " Manitoba seedlings " failed to develop their cones properly. It is suggested that a Research Sub-Station is required where these valuable varieties can be tested on a heavier, cooler soil. Many of the New Varieties, however, flourished in the dry season, " Bullion Hop " (Q43) cropping at the rate of 29½ cwt. to the acre and " Brewer's Gold " (C9a) at 25½ cwt. The average yield per acre of " Bullion Hop ", over six years, now stands at 26½ cwt., and of " Brewer's Gold ", over twelve years, at 26¾ cwt. The number of bushels (Imperial) of green hops required to the cwt. of dried hops varied from 68 to 128. The first-named figure is believed to be the lowest ever recorded. Eleven New Varieties proved on analysis to be richer in preservative qualities than the richest old variety (" Early Bird ") grown at Wye College. The variety " Nonsuch Hop " (OB53) and its clone-plant (bud sport) OM26, at East Malling, were richer in preservative value than the richest sample of imported American hops obtainable, while HH44 equalled it. A growth of the " Nonsuch Hop " at Wye College gave a P.V. of 15·49 (with 10·67 per cent. of α-resin), beating the richest American hop (" Sonoma ") by no less than 3·01 per cent. Two growths of " Bullion Hop " (at Ticehurst, Sussex and Wye, Kent) and one growth of " Brewer's Gold " (at Goudhurst, Kent) were also richer in preservative properties than the American hop, the Ticehurst " Bullion Hop " by 1·35 per cent. Tables are given of the preservative values of growths of " Brewer's Gold " and " Bullion Hop ", and four other New Varieties from various districts in this country and also abroad. The valuations fixed by the H.M.B. on various growths of some of the New Varieties are given. Growers are advised to press for the addition of chemical analysis to the physical examination of hops as a scientific method of valuation, since it has been clearly shown in brewing tests that physical examination alone is not a proper criterion of true brewing worth. Notes are given on the results of recent brewing trials with certain of the New Varieties. These trials give additional evidence that certain of the New Varieties could replace the imported American hops with no loss, but rather gain, to the brewer, as regards both preservative properties and flavour. The view is expressed that the planting up of these " Wye Varieties " under a fresh quota with an amount corresponding to the crop produced deducted from the brewers' quota of imported American hops, would be to the advantage of the industry and very obviously to the national interest. The results show also that the method of physical examination alone in the valuation of hops is not a proper criterion of true brewing worth.

The incidence of Downy Mildew, Mosaic Disease and Verticillium Wilt is recorded.

The Control of the Hop Red Spider. A. M. MASSEE and R. M. GREENSLADE. Rep. E. Malling Res. Sta. for 1940 (1941), 94. (D162.)

See also Plant Pathology, Mycology and Bacteriology. C167.

IX. TECHNICAL SECTION

The chief work of the Technical Section has been to organize the many visits paid by members of the staff to fruit farms in the County in connection with the fruit survey carried out by the Kent War Agricultural Executive Committee under the supervision of Mr. W. G. Kent. The Section has continued also to keep the Station in touch with members and other enquirers through the medium of advisory correspondence. Monthly contributions on matters of interest to fruit and hop growers have been made to the Kent Farmers' Union Journal, and a total of thirteen popular bulletins was published during the year.

Section III

RESEARCH REPORTS

POMOLOGY

LOW TEMPERATURE INJURY TO FRUIT BLOSSOM

II. A COMPARISON OF THE RELATIVE SUSCEPTIBILITY AND EFFECT OF ENVIRONMENTAL FACTORS ON THREE COMMERCIAL APPLE VARIETIES

By C. P. FIELD

Introduction.—The disastrous frosts of May, 1935, led to the initiation of a train of experiments the importance of which to the fruitgrower has been emphasized by the weather at this time of year in subsequent seasons. An account of the preliminary experiments in 1938 in which the effects of exposure to low temperature upon the blossoms themselves and the environmental conditions which determine susceptibility and resistance were examined has already been given (Field, 1939). Further experiments were carried out in the following years, 1939-41 to study in more detail the factors underlying the damage caused by low temperatures, and the results are described in the present article.

Material and Methods. In 1938 material was limited by another spring frost to two late flowering apple varieties and to blackberries. In the next year, however, no frosts complicated the investigation and accordingly the three commercial varieties of apple, Cox's Orange Pippin, Bramley's Seedling and Worcester Pearmain were used. All three varieties are of first class commercial importance, while the last two had in previous seasons exhibited marked susceptibility and resistance respectively to frost damage. The general methods of experiment were the same as in 1938 (Field, 1939). Blossom on twigs from 4 to 12 inches long was cut from the trees. A pad of damp cotton-wool was placed over the cut end of the shoot, and the blossom was then exposed on a table in constant temperature chambers ranging from 32° F. to 26° F. at the Ditton Laboratory for periods of 1, 2, 3, 6 and 12 hours.

Nature of the Damage.—(1) *Styles and Ovaries.*—As before the symptoms of damage occurred in the same characteristic sequence whether produced by a short exposure at a relatively low temperature, or a longer exposure at a slightly higher one. Similarly the first injury to appear was loosening of the ovary skin. This was followed by browning of the styles and petals, and later the death of certain tissues within the ovary, the brown discoloration spreading from the styles, through the placenta to the ovules (Fig. 1). In Bramley's Seedling flowers, sometimes only one or two styles became brown,

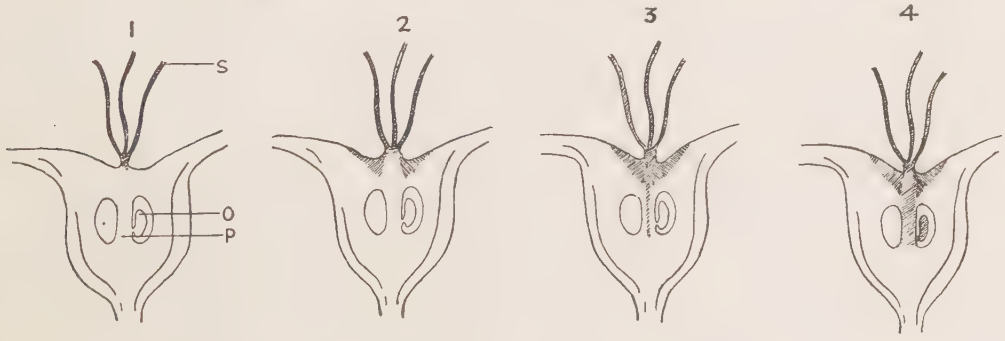

FIG. 1.

the others remaining apparently undamaged; in Worcester Pearmain occasionally only the tips of the styles were discoloured.

The blossom being cut from the trees, it was impossible to trace its development further; but

later, in 1940, trees growing in pots were exposed to a temperature that by then was known to give a definite type of damage to the flowers, and the set of the fruits observed. Five- to eight-year-old trees of Cox's Orange Pippin, Worcester Pearmain, Ellison's Orange and Stirling Castle on Nos. IX and II were available. The pots were insulated to prevent root damage. Pieces of blossom cut from the trees were exposed simultaneously and these showed similar injury to those remaining on the trees —thus forming a useful check on the methods used in the main investigation.

No fruits were produced from flowers with any damage to the style in the pink buds and fully open blossoms, but flowers with only loosening of the ovary skin did develop fruits. This result agreed with the observations of Dorsey (1940) and of Rosen (1936) in the United States of America.

Thus, while the degrees of injury described here are useful indicators of relative susceptibility and resistance, all except the first are probably fatal to the production of fruit.

(2) *Anthers and Pollen.*—The anthers were not damaged until after longer exposures to low temperature, appearing orange in colour when injured.

Microscopic examination of the damaged anthers revealed that some only of the pollen grains had turned orange and these were smaller and showed no granular contents. The orange coloured grains were evidently killed, since they would not plasmolyse like the others, or show any germination when placed on suitable sugar media.

Germination tests were made of the pollen of Bramley's Seedling and Cox's Orange Pippin after exposure to low temperatures, using a 6 per cent. solution of dextrose for the former and 12 per cent. for the latter.

It was found that some pollen grains would withstand as much as six hours exposure to a temperature as low as 26 F. and still show plasmolysis and germinate, although the rate of germination was much slower and the number of viable pollen grains also less.

Protsenko (1939), working in Russia, described how the influence of low temperature on the germination of pollen began to show at 28° F. and the germination diminished in relation to the length of time of exposure. Chandler (1913), however, reported that pollen of Cillago apples germinated after exposure to temperatures as low as —8° C. (17·6° F.), and Jonathan —3° C. (26·6° F.).

To test their susceptibility when germinating, pollen grains were removed from the anthers of the three varieties of apple and allowed to germinate on glass slides in a gelatine and sugar solution (10 g. sugar, 1 g. gelatine in 100 c.c. water) before subjection to low temperatures. The length and position of the pollen tube was noted before exposure to freezing, and subsequently examined for any elongation. There was no further growth even after only ½ hour at 29° F., showing that susceptibility is much increased after germination.

Comparative Susceptibility of the Three Varieties.—(1) *Temperatures causing damage.*—All varieties withstood twelve hours exposure to temperatures above 29° F. This does not materially disagree with the observations of Dorsey (1940), who found that ice masses began to form in succulent apple tissues at approximately 28° F.

TABLE I.

MINIMUM HOURS OF EXPOSURE CAUSING DAMAGE.

Temperature °F.	Bramley.	Cox.	Worcester.
29	2	2	4
28	1	1	2
26	½	½	½

Table I shows the minimum hours of exposure required to damage the three varieties in the 1939 experiments at different temperature levels.

Two hours at 29° F. were sufficient to show damage in Bramley's Seedling and Cox's Orange Pippin, but only 1 hour at 28° F. and ½ hour at 27° F. or 26 °F. Worcester Pearmain required 4 hours at 29° F. and 2 hours at 28° F. but still only ½ hour at 26° F. Thus Bramley's Seedling and Cox's Orange Pippin were more susceptible to injury than Worcester Pearmain.

(2) *Stage of blossoming.*—Susceptibility varied according to the stage of blossoming as is shown in Table II.

The green bud stage was generally the most susceptible. Thus at 28° F. Bramley's Seedling in the green bud stage was injured after 1 hour, in the pink bud and full flower stages after 2 hours, and at petal-fall after 3 hours. In Cox's Orange Pippin the most resistant stage was full flower and

TABLE II.

MINIMUM HOURS OF EXPOSURE AT 28° F. REQUIRED TO DAMAGE FLOWERS AT VARIOUS STAGES OF DEVELOPMENT.

Stage.	Bramley.	Cox.	Worcester.
Green bud ..	1	1	2
Pink bud ..	2	2	6
Full flower ..	2	3	2
Petal fall ..	3	2	6

in Worcester Pearmain, pink bud. Thus Bramley's Seedling showed increased resistance with increased development of the flowers from green bud to petal-fall stage. Cox's Orange Pippin, however, was more susceptible at petal-fall than when the flowers were fully open, and the order for increasing resistance in Worcester Pearmain was—green bud, full flower, petal-fall, pink bud. At each successive stage of blossoming Bramley's Seedling was more susceptible than Worcester Pearmain, the difference being greatest at the pink bud stage.

(3) *Position of Flower on the Truss.*—In two experiments, in which 160 trusses of Cox's Orange Pippin were examined, differences in the proportions of damaged flowers in different positions on the truss were observed. Of the king or topmost flowers 31 per cent. were injured, whereas those in the third and fourth positions counting from the top had 52 and 53 per cent. damaged, respectively. These differences may have been due to stage of development, however, for this does vary slightly according to position. Thus the king flower is usually more advanced and so probably more resistant.

(4) *Moisture Content.*—The marked differences in susceptibility between Bramley's Seedling and Worcester Pearmain, and between flowers of each variety at different stages of their development, do not appear to be due to differences in moisture content, although a low moisture content is sometimes associated with frost resistance.

Determinations were made, both in the 1938 and 1939 experiments, at all stages of blossoming. Very little variation was revealed. From the tightly closed green buds to the fully opened flowers the moisture content only varied from 79 to 82 per cent. Only at petal-fall was there a slight reduction to 77 per cent. It was particularly interesting that varieties such as Bramley's Seedling and Worcester Pearmain, whose flowers appear so entirely different, had practically identical moisture contents.

Environmental Factors Determining Damage.—(1) *Effect of Moisture.*—(*a*) *In the Air.*—Day and Peace (1937) have recorded that the relative humidity of the air during frosts varied from below 75 to 90 per cent. In the foregoing studies with apple blossom the humidity of the air in the constant temperature chambers was maintained at 90 per cent. However, in a series of experiments which need not be described in detail variations in air humidity of from 70 to 90 per cent. did not affect the damage caused to blossoms by exposure to 28° F. and 26° F. for varying periods.

(*b*) *On the Flowers.*—Moisture on the flowers before freezing (apart from humidity of the air) had a marked effect on damage in the first year's experiments (Field, 1939). This was confirmed for Bramley's Seedling flowers in 1939. The differences between dry and wet flowers were less marked in the bud stage, but very obvious in fully open flowers and at petal-fall. Thus at 29° F. one hour did not damage dry flowers and after four hours the styles only were affected. Wet flowers, however, had skin loosening after one hour and the styles and ovules damaged after only two hours. It was observed that a film of ice formed on the surface of the wetted material; but it is not at present possible to say whether this caused mechanical damage.

TABLE III.

MINIMUM HOURS OF EXPOSURE AT 26° F. CAUSING INJURY TO ANTHERS OF DRY AND WET FLOWERS.

	Bramley.		Cox.		Worcester.	
	Pink bud.	Full flower.	Pink bud.	Full flower.	Pink bud.	Full flower.
Dry flower	2	6	4	2	4	2
Wet flower	½	2	1	2	2	½

Anthers also were more readily damaged when the flowers were wet. Table III shows the number of hours exposure at 26° F. causing such injury to dry and wet flowers of the three varieties at two stages of development.

Since wet blossoms were so much more susceptible, the behaviour of wilted flowers, which had lost some of their natural moisture was studied. Only slightly less damage was found in wilted flowers of Bramley's Seedling and Worcester Pearmain, but all wilted and normal flowers of Cox's Orange Pippin were equally damaged.

(c) *In the Soil.*—The effect of moisture in the soil on frost injury to flowers was investigated using pot trees with soil kept dry and wet respectively for five days before freezing. Examination of the flowers after the treatment showed that damage was the same irrespective of whether the soil was dry or wet, but further experiments are needed before it can be definitely stated that soil moisture has no effect.

(2) *Alternate Freezing and Thawing.*—Repeated freezing and thawing for short periods was compared with a single longer exposure to low temperature. Diehl and Wright (1924) found that apple fruits suffered less from two exposures to low temperature of 90 hours than from a continuous exposure of 180 hours, but Day and Peace (1937) found that repeated freezing and thawing was the more damaging to forest trees.

Blossoms of the three varieties were exposed to several short periods of freezing with intervals of thawing between each successive exposure and the injury produced compared with that in flowers which were exposed to one continuous period at the same temperature, the total time in the freezing chamber being the same for all.

The treatments were as follows :—

1. Six separate ½ hour periods at 27° F. with ½ hour intervals of thawing (at 50-60° F.), the total time at 27° F. being 3 hours over a period of 6 hours.
2. Three separate 1 hour periods at 27° F. with 1 hour intervals of thawing, the total time at 27° F. being 3 hours over a period of 6 hours.
3. Three hours continuous exposure to 27° F. without any intermediate thawing.

In all varieties the injury was most severe after a continuous exposure of 3 hours at 27° F., and the least severe when the intervals of freezing and thawing were short and more frequent.

The differences were even more marked in a repetition of this experiment with the temperature at 26° F., in which the damage was compared in blossoms exposed to four quarter-hour periods of freezing and thawing with that in others given two half-hour periods and a third group with one full hour at 26° F. There was no injury in the blossoms which had four repetitions of freezing and thawing, which is surprising at such a low temperature, and only slight damage in some flowers with the half-hour periods, but severe injury after one continuous hour at 26° F.

(3) *Rate of Cooling and Thawing.*—The rapidity of freezing and thawing is considered by many workers to influence the amount of injury. Freezing is usually a fairly gradual process under natural conditions. The temperature tends to fall slowly during the night, and the minimum is often reached at about dawn, whereas the rate of thawing is on the average more rapid. Cox's Orange Pippin flowers were cooled slowly by exposure to 30° F. for three hours before the freezing temperature of 28° F. and compared with others cooled rapidly by being placed immediately in 28° F. The slowly cooled flowers had only skin loosening, but in the rapidly cooled ones the damage extended to the ovules. Thus the severity of the frost damage may depend not only on the minimum temperature reached, but also on the rate of fall of temperature.

Experiments on the rate of thawing were also carried out but the damage was the same whether the blossoms were thawed rapidly or slowly.

(4) *Hardening of the Blossom.*—It has been suggested that when a severe frost is preceded by a series of mild non-injurious frosts the damage may be less than that caused by a sudden drop in temperature after a warm period. In 1938 an attempt to reproduce these conditions by hardening the flowers in a non-injurious temperature of 38-34° F. was not successful. The following year, however, blossoms of the three varieties were exposed for six hours to a safe temperature of 32° F. on four consecutive nights and then subjected to a damaging one of 27° F. for 1½ hours on the fifth. The damage was less severe in the hardened flowers. About half the hardened flowers showed injury to the styles with skin loosening only, the remainder had slight placenta damage also, but in the non-hardened flowers the damage had spread as far as the ovules.

(5) *Freezing after Lime-sulphur Spraying.*—The effect of freezing after lime-sulphur spraying was tested using 5, 2½ and 1 per cent. lime-sulphur solutions on Cox's Orange Pippin. Comparisons were also made of flowers wet with spray and others dry at the time of freezing.

There appeared to be no correlation between damage to flowers and treatment with the spray except in the wet series wherein the flowers wet with the more concentrated solutions were less damaged. It was surprising that flowers wet with spray were not always more damaged than the dry ones. In this series there was no spray damage on spur leaves.

TABLE IV.

DAMAGE AFTER FREEZING FLOWERS PREVIOUSLY SPRAYED WITH LIME-SULPHUR.

Treatment.	Percentage Flowers damaged.	
	Wet.	Dry.
Control	53	47
1% Lime-sulphur ..	49	72
2½% ,, ..	29	21
5% ,, ..	22	54

(6) *Effect of Damaged Foliage.*—In 1941 much wind damage to leaves of fruit trees during the blossoming period afforded an opportunity to test whether blossoms surrounded with damaged leaves were more susceptible to frost than those with normally developed spur leaves.

Cox's Orange Pippin blossoms in the pink bud stage were collected from six-year-old trees on rootstock Malling No. II at West Peckham. There was no frost injury to the flowers, but some spurs had severely damaged leaves and retarded buds, others slightly damaged leaves and normally developed buds, and some spurs had leaves quite uninjured. The blossoms were then exposed to low temperatures. Forty-five per cent. of the flowers with normal leaves were damaged, whereas 64 per cent. of those with slight leaf damage and 79 per cent. of the retarded flowers with severe leaf damage were affected. Thus the greater the previous injury to the leaves the more susceptible the flowers to frost, though at least part of the difference may have been due to the retardation of the blossom.

Possible Methods of Amelioration.—(1) *Spraying with Cold Water.*—The practice of spraying with cold water after freezing has often been recommended for the prevention of damage to fruit blossoms, though Day and Peace (1937) found it ineffective for forest trees.

In this series of experiments, some flowers were sprayed or immersed while still in the freezing chamber and then removed immediately, while others were sprayed with water directly after removal from the chamber.

The amount and degree of injury was in no instance different from that in unsprayed blossoms.

(2) *Effect of Glycerin, Sugar and Calcium Chloride.*—Further attempts to produce resistance were made by the introduction into the plant of glycerin, sugar, and calcium chloride. The experiments with blackberry flowers in 1938 (Field, 1939) showed that the absorption of glycerin by the plant was effective and it was hoped that spraying the flowers might also prove successful.

In 1939, the experiment was extended to apples and the various methods of introducing glycerin, sugar, and calcium chloride are indicated in Table V.

TABLE V.

METHODS OF INTRODUCING GLYCERIN, SUGAR, AND CALCIUM CHLORIDE INTO FLOWERS.

	Length of branch or shoot.	No. cc.	No. days.
Branch Injection :			
1% glycerin	5 ft.	680	2
1% sucrose	5 ft.	250	3
Absorption by cut shoots :			
1% glycerin	4 ft. 6 in.	12–15	1
5% glycerin	4 ft. 6 in.	10–12	1
1% sucrose	4 ft. 6 in.	6–7	1½
2% sucrose	4 ft. 6 in.	4	1½
1% calcium chloride	4 ft. 6 in.	5	1½
2% calcium chloride	4 ft. 6 in.	4	1½
Spraying tree :			
1. Dilute glycerin, 25 cc. in 75 cc. water.			
2. Concentrated glycerin, 75 cc. in 25 cc. water.			

All these treatments were successful in producing a certain amount of resistance, some more so than others. There was practically no damage in Bramley's Seedling flowers which had absorbed 5 per cent. or 1 per cent. glycerin through the shoots when subsequently exposed for two hours at 27° F. Those that had absorbed calcium chloride had damage to the styles only, which, however, though not as severe as in the controls, would be fatal to fruit set. Sucrose was least effective in reducing injury.

Spraying a tree of Edward VII with a dilute solution of glycerin (25 cc. in 75 cc. water) decreased susceptibility to frost damage on the same day and up to three days after spraying.

In 1940 this was repeated using a tree of Cox's Orange Pippin and a more concentrated solution of glycerin (75 cc. in 25 cc. water). The flowers were then exposed to freezing temperatures the same day and every following day for five days. The resistance of sprayed flowers again lasted for three days after spraying (Table VI).

TABLE VI.

PERCENTAGE FLOWERS DAMAGED BY FREEZING AFTER SPRAYING WITH GLYCERIN.

Time of spraying before freezing.	Percentage damaged.	
	Sprayed flowers.	Unsprayed flowers.
Immediately ..	28	73
2 hours	28	77
1 day	48	73
2 days	53	77
3 days	29	42
4 days	64	28

Discussion.—These experiments have confirmed the field observations of the last few years that there are definite differences in the susceptibility or resistance of different varieties at different stages in the development of their flowers, quite apart from the earliness or lateness of their season, but up to the present no real light has been thrown on the reason for these differences. It seems, therefore, that the most desirable development for the immediate future would be an intensive study of two varieties, such as Bramley's Seedling and Worcester Pearmain, which show marked susceptibility and resistance, with a view to discovering any morphological, anatomical or chemical differences in the flowers or foliage at the time of flowering, which might have an influence on their reaction to low temperatures.

If such differences are found, studies could be continued (in the freezing chambers) to try to find out if the susceptibility or resistance of these two varieties can be altered by modifying any of the characters in which they differ.

If the fundamental reasons for resistance can be elucidated, they may point to remedial measures of practical value. Further, in the breeding of new varieties, attention to the characters which make for resistance in the selection of parents, may help to build up a race of varieties of commercial value which are at the same time less susceptible to the vagaries of the weather.

The results of repeated freezing and thawing seem to indicate that the low temperature must prevail for a certain minimum continuous period before damage results. This minimum period is probably the time required for ice crystals to grow in the intercellular spaces in sufficient quantity to withdraw water from the protoplasm to a damaging extent. When this minimum period is not reached, it seems probable that the water can be drawn back by the protoplasm as thawing proceeds.

Such remedial measures as have been tried here have given interesting results, especially spraying with glycerin ; but the comparatively short period of added resistance will have to be much extended if it is to be of any real use.

The increased susceptibility of trusses with injured leaves suggests that greater care to avoid spray damage to spur leaves in the green bud and pink bud lime-sulphur applications may be well repaid.

Acknowledgements.—The writer wishes to thank the Superintendent of the Ditton Laboratory, Dr. C. West, for his kindness in providing facilities for the carrying out this work ; and to Mr. T. N. Hoblyn for his advice in the presentation of this paper.

Summary.—The investigations initiated in 1938 to test the resistance or susceptibility of fruit blossoms to frost damage by exposing blossoms cut from the trees to varying degrees of frost in constant temperature chambers, were continued during 1939, 1940, and 1941. Three commercial apple

varieties, Cox's Orange Pippin, Bramley's Seedling and Worcester Pearmain, were used. The development of the injury was found to follow a characteristic sequence from loosening of the ovary skin to a discoloration spreading from the styles to the ovules. Fruits were found to develop only when the damage was limited to skin loosening. Temperatures above 29° F. did not affect the flowers. The three varieties showed marked differences in susceptibility and in the stages of development at which the flowers were most vulnerable. Generally they were most easily injured in the green bud stage. King flowers on the truss were least susceptible, but this may have been due to a more advanced development. No correlation between resistance and moisture content of the flowers was found; indeed the moisture content of the flowers of different varieties and at different stages of their development did not vary appreciably.

Humidity of the air and soil moisture had little effect on the amount of damage, but wet flowers suffered much more than dry ones. A single exposure to low temperature of three hours proved much more damaging than several short periods adding up to the same time in the chambers, but with intervals to allow the flowers to thaw. Blossoms hardened by exposure to a temperature of 32° F. on four nights before subjection to frost were less damaged than those exposed to a sudden temperature drop. Blossoms sprayed with lime-sulphur at varying strengths and exposed to frost *while still wet* showed less damage with the higher concentration of the wash, but there was no difference when the flowers were allowed to dry. Where the spur leaves were damaged and the blossoms retarded by cold winds, frost injury was more severe than in normal flowers with undamaged foliage.

Spraying with cold water after freezing did not mitigate the damage, but the introduction of glycerin by injection, absorption or spraying gave comparative resistance up to three days after treatment.

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WEATHER CONDITIONS DURING 1941

By H. C. CHAPELOW and H. M. TYDEMAN

Probably the most outstanding feature of the weather during 1941 was the exceptionally long continued period of very cold conditions which persisted from the beginning of the year almost to midsummer. Temperatures were unusually low, especially during January and February, while ground frosts were very frequent and several considerable falls of snow were recorded. During April and May, when all varieties of fruits were in flower, conditions continued abnormally cold. Ground frosts were frequent and, in one or two instances, exceptionally severe, with the result that most kinds of fruit failed to set more than a partial crop. The weather during this period showed several features of unusual interest which can be most readily seen in the diagram reproduced on page 37. This diagram and the notes which follow were prepared by Mr. T. N. Hoblyn, through whose kindness we are able to reproduce them here.

The periods during which representative fruits were in flower are shown near the foot of the diagram with the date of full bloom marked with a cross. Thus, Myrobolan plums opened their first blossoms on 30th March, were in full bloom (50 per cent. flowers open) on 13th April, and finished their blossoming season on 18th April. In the centre of the diagram the daily maximum and minimum temperatures recorded in the Stevenson Screen are graphed. Ground frosts are indicated by a cross. At the top of the diagram a thick black line marks the days when the wind was in the north, north-east or east. At the bottom the daily rainfall in inches is also illustrated.

Four severe frosts were recorded, on 31st March, 4th May, 11th and 16th May. In addition there were nine ground frosts in April and twelve in May. All fruits were either in blossom or at

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1941.

	Temperature in Screen.					No. of Ground Frosts.	Rainfall.			Sunshine.			Soil Temperatures.		
	Mean Maximum.	Mean Minimum.	Highest.	Lowest.	Mean.		Total in inches.	Heaviest fall in a day.	25 years' average.	Total Hours.	Average per day.	25 years' average.	4 inches.	8 inches.	2 feet.
January	37	30	48	13	33	19	2·68	·53	2·42	23·0	0·7	47·2	35·5	36·4	38·1
February	44	33	54	21	39	15	1·95	·47	1·90	61·6	2·2	68·5	36·7	37·3	38·8
March	49	35	57	22	42	16	2·02	·35	1·52	110·5	3·6	121·0	39·9	40·1	41·0
April	50	38	60	30	44	8	1·99	·59	2·09	84·6	2·8	127·7	44·0	43·9	44·8
May	58	38	69	26	48	9	1·43	·45	1·74	161·8	5·2	193·7	51·3	50·9	50·8
June	70	49	88	39	59	0	1·77	·79	1·52	209·7	7·0	203·7	56·2	55·6	54·8
July	76	52	89	43	64	0	2·90	1·2	2·12	242·7	7·8	191·5	66·0	66·0	65·5
August	68	52	73	42	60	0	4·42	·56	2·16	154·7	5·0	182·7	59·0	60·1	61·4
September	67	49	79	36	58	0	0·26	·22	2·20	115·6	3·8	148·9	59·0	59·3	60·0
October	58	43	74	28	51	8	1·25	·39	2·50	104·9	3·4	101·4	47·1	49·1	52·8
November	49	38	56	24	43	7	3·51	1·0	2·95	36·9	1·2	53·9	43·1	44·3	46·3
December	47	31	56	17	39	15	1·87	1·1	2·85	38·1	1·2	38·5	42·4	43·5	45·4
Totals						97	26·0		26·0	1344·1		1478·7			

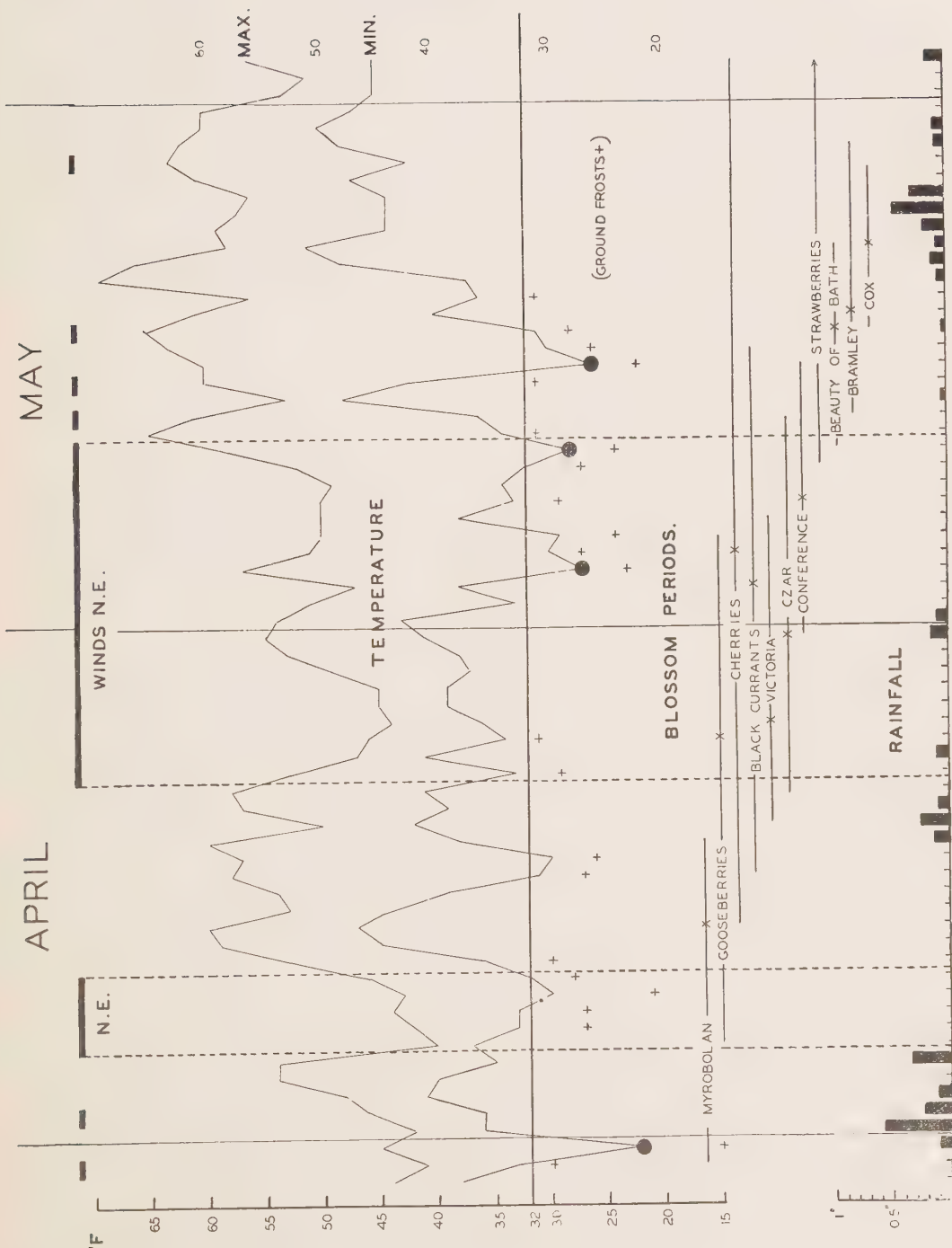

Diagram to show the Weather recorded during the Blossoming Season 1941.

the frost-susceptible "green bud" stage during one or more of these frosts. Cold winds prevailed continuously from 20th April to 11th May covering the greater part of the blossoming periods of black currants, plums and pears. After a spell of wet weather at the beginning of April there was little rain until the last week in May. The effects of these adverse weather conditions on the crops actually realized at the Station are discussed more fully in the Farm Report (see page 11).

A sudden rise in temperature on 15th June, restored more normal conditions, fine sunny weather continuing until the end of July. A period of prolonged wet with lower temperatures during August was followed by a warm and sunny September and October.

Although the total rainfall of the year (26·0 inches) was exactly the same as the 25 year average here, its distribution was somewhat unusual. August was the outstandingly wet month with more than twice the average, while March and November were also somewhat wetter than usual. On the other hand September was exceptionally dry, while in October and December only about half the average rainfall was recorded.

The year's total of sunshine (1,344 hours), was 134 hours less than the 25 year average. The most notably deficient month was January with less than half the expected quantity while in April and November only about 70 per cent. of the average was recorded. On the other hand, July was very sunny with more than 50 hours in excess of the normal.

PLANT PHYSIOLOGY

FURTHER NOTE ON THE REDUCTION OF PRE-HARVEST DROP IN APPLES BY USE OF DILUTE SPRAYS OF ALPHA-NAPHTHALENE ACETIC ACID

By M. C. VYVYAN

In a former report (Vyvyan, 1941) it was shown that a very dilute spray of α-naphthalene acetic acid can considerably reduce the drop of mature apples from trees of Cox's Orange Pippin, Worcester Pearmain, and Beauty of Bath. Similar results with other varieties of apple had already been reported from the U.S.A. and elsewhere, and have since been widely confirmed. Further experiments at East Malling, on a fourth apple variety, Miller's Seedling, have given similar results and will be described in this note.

It was pointed out in the former report that it was not known whether this substance was harmful or harmless to animals and it was mentioned that Dr. Haddow of the Chester Beatty Research Institute was investigating this problem. It was suggested that the use of this substance, as a spray for fruit to be used for human consumption, should be postponed until those experiments had shown it to be harmless. These experiments are not yet quite complete, but Dr. Haddow has authorized the following statement: "No carcinogenic or other harmful effect has been obtained in experiments with α-naphthalene acetic acid carried out for more than a year." Moreover, Shear (1941) has recently tested other somewhat similar growth substances, indole-3-acetic acid, indole-3-butyric acid, and indole-3-propionic acid for carcinogenicity in mice and has got negative results.

It is extremely improbable, therefore, that any harm would result from even comparatively large amounts of the substance, such as used in Haddow's experiments, let alone from the smaller amounts used in the application of solutions as dilute as 5 or 10 parts per million.

Under these circumstances it seems reasonably safe to use sprays of α-naphthalene acetic acid, at these concentrations, on commerical orchards of fruit that will be subsequently put on the market, especially as sprays of this type have for some time been recommended, and used on a considerable scale in the U.S.A., where several proprietory products, embodying this substance, are already on the market.

Description of Experiment.—Twenty-seven mature trees of Miller's Seedling were used; these were grouped in nine blocks of three trees. One tree in each block was sprayed with tap water as a control (A), the other two received sprays containing α-naphthalene acetic acid at concentrations of 5 parts per million (B) and 10 parts per million (C) respectively. The sprays were applied on the 7th August, 1941. The fruit on other trees of the same variety on the same plot were picked on the 28th August, but those on the trees in the experiment were left on the trees for a few extra days to get some evidence of how long the effect of the spray persisted. By the 3rd September the rate of

dropping had become very heavy so the remaining fruit were picked, counted and weighed. As in the former experiments, the drops under each tree were collected, counted and weighed at intervals of a few days from the time of spraying until the time of picking, and the number of fruit present on each tree at the time of spraying, and on subsequent dates, determined from the final number of fruit picked and the number of drops.

Table I.

Effect of α-naphthalene acetic acid sprays on Fruit Drop in the Apple, Miller's Seedling.

Number of Apples on Tree.
As percentage of number present on date of spraying.

Date.	Control (A).	5 p.p.m. (B).	10 p.p.m. (C).
7 August ..	100·0	100·0	100·0
8 ,, ..	99·2	99·2	98·8
11 ,, ..	96·7	97·6	96·4
14 ,, ..	93·1	96·0	94·4
16 ,, ..	90·6	95·4	93·7
18 ,, ..	86·7	93·3	92·1
21 ,, ..	82·4	91·9	90·8
25 ,, ..	76·6	88·8	88·3
*28 ,, ..	67·8	83·4	84·2
30 ,, ..	61·7	80·9	82·9
1 September ..	51·6	77·7	80·9
3 ,, ..	34·0	60·0	63·3

* Date when apples would normally have been picked.

Results.—The results are shown in Table 1. The number of fruit remaining on the trees on various dates is shown as a percentage of the number present at the time of spraying. It will be seen that on the 28th August, the date when the fruit would normally have been picked, the trees sprayed with 5 p.p.m. and 10 p.p.m. still retained 83·4 and 84·2 per cent. respectively of their fruit, while the control trees retained only 67·8 per cent. The rates of dropping were calculated and analysed statistically in the manner described in the former report (Vyvyan, 1941) but are not given in the Table. These showed that the rate of dropping was significantly reduced, by the treatment, within a week of the time of spraying and the reduction was still thoroughly significant after the 28th August, more than three weeks after the time of spraying. This suggests that, with this variety, an even greater saving of fruit might have been attained by spraying a week or so earlier. There were no significant differences in rate of drop between the two treatments, 5 p.p.m. and 10 p.p.m. and there is therefore no reason to use the higher concentration.

The average weight per apple at the time of picking was about the same under each treatment ; it was (A) 0·179, (B) 0·175, and (C) 0·177 lb. This works out at about 226 apples per bushel (40 lb.). The numbers of apples on nine trees at the time of spraying were (A) 6534, (B) 6034 and (C) 7275, giving a mean of about 735 apples per tree. The potential crop was therefore about 3·25 bushels per tree. The percentages remaining on the tree on the 28th August were about 68 (A), 83 (B) and 84 (C) respectively, or in terms of bushels per tree, about 2·2 bushels on the control and 2·7 on the treated trees. On the basis of 100 trees per acre, this would mean a saving of about 50 bushels per acre, but, as many of the drops from untreated trees may be marketable, it would be safer to take a more conservative value, say 10 bushels per acre. In the experiment about two gallons of spray were used on each tree. Two hundred gallons of spray, at a concentration of 5 parts per million, would require only 5 g. of α-naphthalene acetic acid, which, at the present price, would cost 12s. Add the cost of labour, and the total cost of spraying an acre would be less than £2. Economically, therefore, the application of the spray would be well worth while. As many growers might find it inconvenient to put on an extra spray at this time of year, the effect of mixing the substance with the last normal routine spray will be examined.

The substance, α-naphthalene acetic acid, can be obtained from several chemical firms. It is almost insoluble in water, and it should therefore be dissolved in a little alcohol, which can then

be mixed with the water in the tank. A tablespoonful of alcohol is sufficient for 5 g. of the substance.

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MYCOLOGY AND BACTERIOLOGY

NOTES ON PLANT DISEASES IN 1941

By H. WORMALD

Brown Rot Diseases.—The numerous mummied fruits seen on plum trees during the winter of 1940-1 testified to the heavy infection during the summer of 1940. Many of these mummies remained on the trees until spring, either from neglect or from lack of labour, and in 1941 there were again outbreaks of Wither Tip, Blossom Wilt, and Brown Rot of the fruit.

In June, twigs of *Pyrus japonica*, a popular flowering shrub, were brought in from a garden at Teston (near Maidstone) with clusters of dead flowers bearing many pustules of *Monilia cinerea*, the fungus causing Blossom Wilt of plums and cherries. Previously I have met with this disease on "Japonica" on two occasions only, in gardens both in the neighbourhood of Maidstone. It should be noted that infected bushes of *Pyrus japonica* may serve as sources of infection for stone-fruit trees in the vicinity.

Blossom Wilt of Lord Derby apple trees was prevalent in some areas. One attack, in East Kent, was so severe that the trees lost practically all their blossom, and were so badly damaged that there seemed to be no alternative but to grub the trees, or at least to cut them back hard and top-graft them with a less susceptible variety. Later in the season (early September) apples showing the Black Apple disease were sent in for examination. This rot, caused by the Brown Rot fungus *Monilia fructigena* is common on stored apples and as a rule is not found on apples before they are picked. The apples received, however, had shown the Black Apple condition while they were still on the tree; the variety chiefly affected was Grenadier.

Grey Mould.—In 1941 *Botrytis cinerea* appeared on many species of cultivated plants and on a number of weeds, particularly during two rainy periods of the year. An account of these observations appears on page 44 of this Report.

Armillaria Root Rot.—The losses as a result of root rot caused by the Honey Fungus, *Armillaria mellea* continue to be serious. In 1941 it was found on top-fruit trees in a number of fruitgrowing areas, mostly on mature trees in commercial orchards, but it was also found on a young pear tree from a private garden. In addition it was seen on raspberry stools from North Kent and Surrey, and on hops in Kent.

The affected raspberries in Surrey were in a plantation about twenty years old and the disease (from the account received) "appears to be spreading rapidly". In the specimen examined the main root showed, beneath the bark, the white layer of mycelium typical of Armillaria, and rhizomorphs were present, thus confirming that the roots were infected with Armillaria.

A Stalk-End Rot of Apples.—About the middle of August two half-grown apples showing a rot at the stalk end were received from a garden in Surrey. One of the apples bore *Botrytis cinerea*, the other a species of Phoma. At request the grower sent more specimens showing the same kind of rot; some bore Botrytis but on most of them were Phoma fructifications. It was then seen that two species of Phoma were present, so they were isolated in pure culture and later inoculated into mature apples; it was found that each of them was able to produce a definite fruit rot.

The association of these three fungi having parasitic tendencies with a stalk-end rot of half-grown apples on the tree suggests that under certain conditions of weather, and possibly cultivation, they may become actively parasitic. As so little is known about this disease growers who find young apples affected with a stalk-end rot are asked to send specimens to this Research Station so that further study of it can be made.

Pear Canker.—Conference pear trees are rarely damaged by canker caused by the common apple canker fungus, *Nectria galligena*, but one case of severe cankering on this variety was observed in 1941, at Marden, Kent. The main branches of young trees were girdled or nearly girdled by cankers on the two-year-old wood, so that they had to be cut back hard to remove the infected parts. Near the middle of each canker was a pruning cut, made in the winter of 1939-40, and the fungus had evidently entered the trees through the pruning cuts. Over the hedge on one side of the pear plantation, and within a few yards of the pear trees, there were some badly cankered apple trees. It would seem that the pear trees had become infected from the apple trees, for those nearest the apple orchard were most severely cankered. This serves to emphasize a point referred to in the Report for 1940 (p. 56 where severe cankering of young Cox's Orange Pippin apple trees was mentioned) that when young fruit trees (apple or pear) are planted care should be taken to remove all cankers from older trees in the vicinity as these will serve as sources of infection for younger trees, which may develop cankers on the stems or main branches and so become seriously checked in growth. This operation should be carried out before any pruning is done to the young trees.

Blossom Blight of Pear Trees.—This disease was very destructive in Kent and other parts of the country in 1941. On some trees all, or nearly all, of the blossom was destroyed. As pointed out in previous Reports (see particularly the Report for 1940, p. 58) the trusses of affected flowers usually contain dense masses of bacteria, and organisms have been isolated which have been shown by inoculation experiments to be able to infect the flowers and cause blossom blight. It seems probable however that the weather conditions at the time of blossoming have some influence on the intensity of the disease. In 1941 there were frosts in May as the trees were coming into flower and it is suspected that such conditions rendered the flowers more easy of attack.

Blossom Blight and Leaf Spot of Morello Cherry.—In some years the Morello cherry trees on this Station have had a disease affecting the flowers (causing them to wither) and leaves (leaf spots). Although this disease had not been found elsewhere with certainty it was suspected that it was present in other areas also, and in 1941 the blossom blight condition accompanied by leaf spotting was seen in a plantation of Morellos on a fruit farm near Swanley, while leaf spots containing bacteria were found on a tree in a garden at Maidstone. Organisms have been isolated from this material for comparison with strains isolated previously from trees on this Station.

Fomes pomaceus on Cherry Trees.—This fungus was found to be causing serious damage in a commercial cherry orchard at East Malling. The affected trees (thirty to forty years old) were of various varieties, and about 10 per cent. were infected.

Plum Rust.—There were many enquiries about Plum Rust during 1941, and leaves showing severe infection were received from various districts in the south of England, with complaints in some instances of serious premature leaf-fall. Although the disease is confined to the leaves and does no permanent injury the early defoliation must tend to weaken the trees, so attempts to control it should be made in areas where it is serious year after year. Two methods of control are to be recommended (1) removing anemones showing the Cluster Cup stage of the Plum Rust fungus from gardens in the vicinity of plum orchards, and (2) spraying with Bordeaux mixture when the fruit is about half-grown, and again, if the rust shows signs of spreading, immediately after the fruit has been picked.

Die Back of Black Currants.—In April dead black currant branches were brought in from a fruit farm in the Weald of Kent where the soil was rather heavy and wet. There were discoloured portions of bark near ground level but no parasite was detected on the surface. On keeping the specimens in a moist chamber, however, yellow "tendrils" of spores exuded through the bark and the fungus was identified as *Cytosporina Ribis*. Later, in another part of Kent where the soil was lighter, bushes were found with branches bearing laterals which wilted as they were just coming into flower. These again yielded the *Cytosporina*. This fungus has been found occasionally in this country associated with the dying back of currant bushes and it has been suspected of having parasitic habits. In 1938 a French plant-pathologist* concluded from his observations and experiments that *Cytosporina Ribis* is the imperfect stage of *Eutypa lata* var. *Ribis*, and that this fungus is definitely parasitic on black currants. Growers are advised therefore to cut out immediately any dying branches and to burn them, in order to prevent the spread of the fungus; if these dead parts are left lying about on the farm the fungus will continue to grow on them and produce its spores.

Leaf Spot of Gooseberry.—An early severe outbreak of this disease (caused by the fungus *Gloeosporium Ribis*), occurred in a Sussex plantation. The severity of the attack, probably induced by the wet spring, was indicated in the letter (sent towards the end of July) accompanying the specimens; it stated that "many of the leaves inside the trees are dropping off although the bushes are not entirely defoliated". Such early defoliation must have an adverse effect on the general vigour of the bushes. Spraying with Bordeaux mixture after the fruit is picked has been found to control

* Barthelet, J. (1938). "Recherches sur la mortalité des rameaux de Groseilliers." *Ann. Epiphyt. Phytogén.* **4**, 495-512.

the similar leaf spot of black currants, and the same treatment should be carried out on gooseberries in severe outbreaks.

Leaf Spot of Rubus spp. In the early autumn leaves of plants of various species of Rubus on a variety plot were examined to ascertain the relative intensity of Leaf Spot (*Gloeosporium venetum*). The leaves of Loganberry, Himalaya Berry, and Phenomenal Berry were very severely infected, nearly all the leaves having very many spots ; those of Himalaya Berry and Phenomenal Berry were worst where they were near the Loganberry plants, and this suggested that the latter had been a source of infection. Two or three spots were found on Parsley-leaved (A) blackberry and a few more on Parsley-leaved (B), but both these varieties seemed to be very resistant for there was no pronounced spotting, even where their leaves were immediately below severely affected Loganberry leaves.

A Leaf Blotch of Strawberry.—A disease of strawberry plants which had not previously been put on record for Britain was observed in August in a garden at Trottiscliffe. Some of the blotches were so large that they sometimes extended over the greater part of a leaf. The affected plants were growing in the shade of trees and this together with the high rainfall in late spring accounted for the severe outbreak on these plants. To enable growers to recognize this disease a description is given on page 44.

Corticium Disease of Turf in a Cover Crop.—Towards the end of July the fungus *Corticium fuciforme* was found on a cover-crop plot of mixed grasses. This is the fungus causing the Corticium disease of turf which is troublesome on golf greens. If the fungus should get established on grass cover-crops it might become a nuisance, but in this particular instance it was not causing any appreciable damage. It was noticed as a bright pink patch about two inches in diameter ; this was found to consist of fine fungal threads extending over the grass leaves, with needle-shaped outgrowths near the tips of the leaves. The fungal strands bore numerous fructifications (basidia) bearing spores. The eradication of such a small patch would be an easy matter, but if left it would probably increase and extend to other parts of the plot.

Summary.—Observations on certain diseases observed on fruit farms during 1941 are summarized with particular reference to the relation of their incidence to local weather conditions.

NOTES ON HOP DISEASES IN 1941

By W. G. KEYWORTH

Verticillium Wilt.—Nine new outbreaks of this disease were reported during 1941. It continues to be a serious menace on many farms and it is becoming increasingly apparent that the control of large outbreaks is likely to prove a most difficult and expensive matter. It is of particular importance, therefore, that observations made during 1940-1 showed that where control measures were applied promptly to small outbreaks these were much reduced in intensity and, on a few farms, apparently eliminated entirely.

Observations have shown that the disease can be spread from one farm to another, possibly by the transport of infected material by the wind, and certain new outbreaks have apparently arisen in this manner from neighbouring older ones.

Further evidence has also been obtained of the introduction of the disease into commercial gardens by the planting of infected sets. About 1,500 sets were obtained by one grower in 1938 from a farm on which, unknown to him, there was an outbreak of Wilt. These sets were used to plant one-third of a garden, the remainder of which was planted with sets from other sources. In 1941 the writer found about sixty small Wilt outbreaks in the part of the garden which had been planted with the suspected sets, the rest of the garden being healthy, and in view of the scattered distribution of the outbreaks it may prove impossible to eliminate them.

Growers are urged to take prompt measures for the control of all suspected Wilt outbreaks. Full information can be obtained on application to the East Malling Research Station.

Nettlehead.—Experiments made during 1940-1 have shown this disease to be transmissible by grafting and it is therefore probably caused by a virus. Control measures at present largely depend on the prompt removal of infected hills, and information on the early recognition of such infected hills is of value.

Observations already made on this point show that weather conditions play a large part in determining the readiness with which diseased hills can be recognized.

In very warm weather the disease symptoms are " masked ". Experimental hills known to be diseased have been found to show no clear symptoms when grown in a warm greenhouse, and during

a hot summer a similar effect is visible out-of-doors. This high-temperature masking and the cultural operations of pulling and training the hills often combine to make disease recognition very difficult throughout much of the growing season.

The effect was shown very clearly during 1941. Nettlehead symptoms were apparent on hills in many gardens in early May before the bines had been trained. Affected hills were stunted—an effect best seen from a ladder, when the small groups or rows of stunted hills were readily distinguished from the neighbouring healthy and freely growing plants. The upward leaf-curling which is the only certain diagnostic feature of this disease was visible on some of the bines on many stunted hills. The bines thus affected were growing stiffly instead of twisting in the normal fashion. It must be emphasized that certain diagnosis of Nettlehead cannot be made on stunting alone as other factors may cause this, but it can be used for a preliminary distinction of suspicious hills, the disease being later confirmed by other symptoms. It is a good plan to mark with lime the stunted hills which are not showing definite symptoms so that they can be observed later.

Since the operation of pulling (in May) involved the drastic thinning of the healthy plants the differences between these and the stunted diseased hills were almost eliminated, an effect which was enhanced by the training of the remaining bines up the strings.

During most of June and July the weather was warm. This caused disease symptoms to be masked and thus, from the time of training until early August, even badly diseased hills showed no clear symptoms. The weather in August was cool and wet, and towards the end of the month, typical leaf curl symptoms were again visible, but only at the ends of laterals and at the tops of the main bines. A fair crop was borne on many diseased hills.

It will be seen that the training of the bines followed by the masking caused by the hot weather, reduced the times when diseased hills could be clearly distinguished to short periods at the beginning and end of the season. As diseased hills are still infective even though symptoms are not visible, it is obvious that every opportunity should be taken to remove them whenever symptoms can be seen, starting very early in the season.

Fluffy Tip.—A widespread and remarkable outbreak of this disorder occurred during the period 26th to 30th June. Numerous enquiries were made by growers from localities as far separated as Benenden, Maidstone and Penshurst, and reports of this trouble were received from East Kent and the West Midlands at about the same time. The disorder was reported as occurring on both the Fuggle and Golding varieties but it was not so prevalent on the latter.

The main symptom was a sudden check to the growth of the bine which was at this time about one or two feet from the top wire. The tip of the bine appeared stiff and stood out from the string, the internodes were shortened, the leaves distorted and reduced in size, and the stipules, which were standing stiffly out from the bine instead of being pressed to it, appeared very prominent. The whole effect was most disquieting as in some gardens up to 50 per cent. of the bines were affected. Fortunately the trouble did not persist on most farms, for the bines grew away leaving a "short-jointed" portion where the check had occurred. On some farms however the check to the bines was permanent and they failed to grow further, fell away from the string, and finally died back for several feet from the tip. On such bines the laterals became reduced in size with distorted leaves bearing ring-shaped yellow markings and dead patches.

The cause of these symptoms is unknown. It is possible that the widespread and transient check to the bine was due to adverse growing conditions, and it is of note that on 14th June a sudden change in temperature occurred, the previous fourteen days of abnormally cool weather being followed by a week when very high temperatures were experienced. The more severe symptoms of bine dieback and leaf distortion are probably due to causes other than adverse weather conditions and this phase of the disorder is being investigated.

Chlorotic Disease.—The first recorded outbreak of this virus disease in the South-Eastern area occurred during 1941 in a Fuggle garden at East Peckham, where it was confined to a few hills. Previously the disease had been seen only in Worcestershire. The symptoms and nature of the the disease as it occurred there have been described by Salmon and Ware.*

Other Disorders.—Split Leaf Blotch was very severe in one Fuggle garden in 1941 and caused a great reduction in crop. Mosaic disease was again widespread in the Golding yards in the West Midland area. Armillaria disease was still present on hops planted three years previously on the site of an old orchard, but repeated grubbing of affected hills and replanting appeared to be reducing the severity of the attack.

Summary.—Notes are given on outstanding features of the attacks of Verticillium Wilt, Nettlehead, Fluffy Tip, Chlorotic Disease, and Mosaic Disease of hops observed during 1941.

* Salmon, E. S. and Ware, W. R. (1930). "The Chlorotic Disease of the Hop." *Ann. appl. Biol.*, **17**, 242-7.

STRAWBERRY LEAF BLOTCH

By H. WORMALD and H. B. S. MONTGOMERY

Further information is required on the distribution and severity of a leaf blotch disease found by the present writers on Royal Sovereign strawberry plants at Trottiscliffe, in August, 1941, and subsequently in six other localities in Kent. A fungus found on the blotches resembles that described for a similar disease on the Continent as *Phyllosticta grandimaculans* (Bubák, 1912), though this may be the same as a fungus described earlier under the name *Zythia Fragariae* (Laibach, 1908).

In this country the disease was first observed by L. Ogilvie at Long Ashton in 1931, and later, in 1939, it was found by C. J. Hickman at Westerham, Kent, but as no account of these earlier observations has been published, the following brief description may enable growers and others to recognize the disease.*

The smallest blotches are almost indistinguishable from the common Leaf Spot, but they never develop the white mould which is the Ramularia stage of the Leaf Spot fungus, and they remain yellowish with a dark border. The larger blotches are pale yellowish brown, but round the edge is a narrow dark purple zone ; they are rather irregular and up to an inch or two inches in diameter. Outside the purple zone affected leaves are sometimes yellowish, the yellow colour gradually becoming merged in the general green of the normal parts of the leaf.

When examined with a hand lens many of the blotches are seen to bear dark dots, which sometimes can just be detected with the naked eye. From these, under moist conditions, mucilaginous globules of spores exude ; the spores measure about 6 by 2μ and each of them contains two small yellowish roundish bodies (guttules), one near each end.

Because of the constant association of the fungus with the blotches it is assumed to be the cause of the disease, but inoculation experiments with pure cultures are necessary for confirmation. The fungus has been isolated in pure cultures for such tests, and strawberry plants for inoculation experiments are being raised.

The disease has been found mostly on Royal Sovereign, but it has been seen on Huxley's Giant also. Growers who see a disease of strawberry leaves similar to that described are asked to inform us so that we can determine whether it is the same disease, and also consider what steps are necessary for dealing with the outbreak.

Acknowledgements.—For assistance in the identification of the fungus and for facilitating access to herbarium material we are indebted to the late Director and Miss E. M. Wakefield of the Royal Botanic Gardens, Kew, Mr. W. C. Moore of the Ministry of Agriculture, Mr. L. Ogilvie and Mr. C. J. Hickman.

Summary.—A strawberry Leaf Blotch, first put on record for this country in 1941, was found in seven localities in Kent during that year.

The chief characters to be looked for in diagnosing this disease are (i) the large, yellowish-brown blotches bordered by a dark line, (ii) the fungal fructifications seen with a lens as rather dark (but not black) dots, (iii) under a microscope the small (about 6 by 2μ) biguttulate spores.

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THE GREY MOULD OF FRUIT AND HOPS

WEEDS AS POSSIBLE SOURCES OF INFECTION

By H. WORMALD

In previous articles (Wormald, 1941*a*, *b*) it was stated that the Grey Mould fungus, *Botrytis cinerea*, had been found on hedgerow plants (bramble and black bryony) and on a weed (dandelion), and that such plants are thus possible sources of infection for cultivated crops. During 1941 a more

* See also a previous article (Wormald and Montgomery, 1941).

detailed survey was made of the host plants of this fungus particularly with reference to its occurrence on weeds in cultivated ground. Attacks on wild plants and weeds may easily be overlooked as having no apparent economic significance, yet the very fact that those outbreaks may be neglected ensures that such plants are sources of prolific crops of Grey Mould spores which are easily carried in the air and may thus infect cultivated plants in the neighbourhood.

In 1941, Grey Mould was widespread ; many cultivated plants were attacked and the fungus was found on a number of weeds. In February it was seen on the heads of Globe artichokes (*Cynara*) that had been left over winter in a neglected garden, and on the catkins of cobnut branches that had been cut off and left lying in the plantation. There were however two periods during the year when the fungus was particularly abundant. The first of these was the first half of June when there was rain or drizzle on most days. Early in the month cabbages in a number of gardens were infected, and a little later it was found on gooseberry (causing die-back), red currant and black currant (flowers), sweet cherries and Morello (flowers), pear (one leaf seen with the fungus on it), quince (leaves), rhubarb (leaves and flowers), mummied plums, strawberry (flowers), and potato (leaves and haulms).* On the potato leaves the most characteristic symptoms were V-shaped brown areas at the tips of leaflets. The fungus was seen, too, on a number of ornamental plants in gardens, including Buddleia (on main stems), *Prunus triloba* (die-back), viola (flowers) and flowering currant (shoots), and also on certain weeds as burdock (old dead stems), creeping thistle (*Carduus arvensis*) and a clod of grass which had been hoed up and left in the field during a time of wet weather, and on the flower heads of dandelion. On the mummied plums it was associated with the Brown Rot fungi ; mummied fruit, if allowed to remain on the trees until spring are therefore not only a source of Brown Rot infection but they may also harbour Grey Mould. Many strawberry flowers that had been killed by frost bore Botrytis fructifications, and such flowers would probably have served to infect the fruit if the weather had remained wet, but, in fact, drier conditions prevailed as the fruit was ripening and there was comparatively little loss from Grey Mould in the strawberry crop.

It was during this period (early June) that so much loss was caused to crops of field beans in the South of England, from infection by *Botrytis cinerea* causing the Chocolate Spot disease. The outbreaks were described by Ware and Glasscock (1941) who state that " the great wave of attack began during the last week of May and the first week of June ".

The presence of the fungus on the old stems of burdock suggests that it had passed the winter within stems killed the previous year. Similarly on the flowering currant (*Ribes aureum*) the fungus was found in spring, on twigs which had been infected and killed in 1940, and, as the young shoots began to develop, they too became infected and withered. Thus early outbreaks of Grey Mould are, sometimes at any rate, to be attributed to the fungus on shoots or stems killed the previous year.

From the middle of June to the middle of July there was a hot dry period which checked the development of Botrytis and there was but little of it to be found, even, as already mentioned, on the strawberry crop, which, in a wet July may be reduced by some 30 per cent. from fruit rot caused by Botrytis. In August *Botrytis cinerea* was found on apples with a stalk-end rot. It had been seen in 1940 associated with an " eye-rot "†, but its appearance as the probable cause of a stalk-end rot of half-grown apples had not previously come to our notice. The variety of apple was not known but it was one with relatively long fruit-stalks so that the fruit showed a tendency to hang down in an early stage of its development. This, in wet weather allowed water to remain for some time in the hollow round the stalk, thus affording conditions favourable for attacks by Botrytis.

The second period of the year when Botrytis was abundant was from the middle of September onwards to the end of October. On 22nd September, in a hop garden near Paddock Wood, *Botrytis cinerea* was found not only on the hop cones, causing a brown discoloration, but also on nettles (*Urtica urens*) field sowthistle (*Sonchus arvensis*), common sowthistle (*S. oleraceum*), and groundsel (*Senecio vulgaris*), all growing as weeds in the same field among the hops. On the affected nettles the fungus had infected the stems near the middle, producing a lesion which caused the upper half of the stem to fall over. On the other weeds the fungus had attacked the flower-heads, and then, growing down along the flower-stalks, caused the heads to droop ; such drooping flower-heads almost invariably bore Botrytis fructifications.

Towards the end of September and in early October *Botrytis cinerea* was found on a number of weeds growing among or near fruit trees. These included the field sowthistle, common sowthistle, groundsel, creeping thistle, cats-ear (*Hypochaeris radicata*), smooth hawk's beard (*Crepis virens*), chicory (*Cichorium Intybus*), knapweed (*Centaurea nigra*), ragwort (*Senecio Jacobaea*), and common hawkbit (*Leontodon hispidus*). On these representatives of the family Compositae the fungus was usually producing fructifications on the flower-heads (capitula), and such plants seem to be particularly

* Most of these specimens were brought to my notice by Mr. M. H. Moore who had come across them when visiting growers plantations in connection with survey work.

† See the Annual Report of this Station for 1940, p.60.

susceptible to infection. It was found, but less abundantly, on flowers of toadflax (*Linaria vulgaris*), and white goosefoot (or fat hen, *Chenopodium album*).

With regard to plants in hedgerows Botrytis was again found on fruits of brambles and on black bryony leaves; these thus appear to be among the most susceptible of hedgerow plants, though possibly further search will reveal other plants of hedges and waste places that are subject to Grey Mould infection.

Certain garden crops also were affected in early autumn; these included runner beans, the pods being infected, and sunflowers. The sunflowers, grown specially for their seed, produced a very rich crop of Botrytis fructifications and must have set free into the air millions of spores. As the flower-heads mature they tend to droop and the channel round the stalk collects rainwater during wet weather, thus affording conditions particularly favourable for the development of Botrytis.

Later still, in November, Botrytis was found on another weed of cultivated ground, the penny cress (*Thlaspi arvense*), on pods and stalks. It was also seen on stored onions.

Of the weeds mentioned, the fungus has been found most abundantly on the two sowthistles, plants which grow vigorously if left undisturbed in cultivated ground. In fruit plantations they grow to a height of two or three feet and under such conditions of shade and a fairly rich soil they appear to be particularly susceptible to infection, while their great height, relative to that of most other weeds of plantations and orchards, allows a ready dispersion of the spores by the wind. The fructifications of the fungus were found occasionally on the fruits of composite weeds as they were ready for dispersion, and the spores may thus be carried to great distances by reason of the pappus which, acting as a parachute, enables the fruits of the weeds to be dispersed to great distances.

The question arises as to whether *Botrytis cinerea* on weeds and other plants can actually infect cultivated crops, or whether there may be biologic forms of the fungus that attack only particular species of plants. Although the fungus species *Botrytis cinerea* includes a number of races, which show differences when grown in pure cultures under laboratory conditions, there appears to be no definite specialization of parasitism and it would seem that a strain found on one host is usually able to infect other kinds of plants also. Thus Wilson (1937) was able to produce the Chocolate Spot disease on plants of field beans not only by a strain isolated from bean but also by strains from arum lily, apple, and rosebud; with the bean strain he induced severe chocolate spotting on the common vetch (*Vicia sativa*), and slight infection on a number of other leguminous plants. Two Russian workers found that strains of *Botrytis cinerea* isolated from sugar beet, the soil, geranium (*Pelargonium*) rose, lemon, Primula, and chrysanthemum were all equally capable of causing storage rot of sugar beet.* Schnellhardt and Heald (1936), in America, found that *B. cinerea* from a number of host plants, including apple and pear fruits, pea pods, and shoots of Geranium and Gloxinia, could readily infect apples.

In experiments carried out at East Malling strains of *Botrytis cinerea*, isolated from some of the host plants mentioned, were inoculated into apples, and Grey Mould rot developed in every case, so the fungus on each of those plants may be considered as a potential cause of storage rot of apples. The strains used were isolated from weeds and from a number of cultivated plants, viz. dandelion, common sowthistle, field sowthistle, groundsel, nettle burdock, creeping thistle, penny cress, black bryony, bramble, French bean, cabbage, carrot, globe artichoke, African marigold, scabious, sweet chestnut capsule, cobnut catkins, and hop cone.

These all readily induced a rot of the fruit although with the strain from hop the development of the rot was not so rapid as with the other strains. After inoculation the apples were kept at laboratory temperature (16° to 18° C.) and evidence that infection had started was to be seen on the third day, by a brown discoloration round each place of inoculation. In eight to twelve days the affected area was from $1\frac{1}{2}$ to 2 inches in diameter; the rot gradually extended until the whole apple became brown, and sooner or later bore fructifications of *Botrytis cinerea*.

Weeds are sometimes deliberately allowed to grow so that they can be ploughed in as a "cover-crop" to supply humus to the soil. This practice is not to be recommended when there are valuable cultivated crops in the neighbourhood that are susceptible to Grey Mould, such as fruit, hops, field beans, or lettuce, and a recognized cover-crop mixture is preferable.† Cover-crop plants are not all immune from Grey Mould, for a few Botrytis fructifications have been found on the flower heads of red clover and white clover, petals of the common vetch (*Vicia sativa*) and the pods and flower-stalks of lucerne (*Medicago sativa*). These plants however would appear to be far less susceptible to infection (and so less liable to harbour Grey Mould) than some of the composite weeds mentioned above, particularly the sowthistles.

* Quoted from *The Review of Applied Mycology*, XIX, 1940, p. 322.

† See "Practical Notes on Cover Cropping of Orchards," by W. S. Rogers, in the *Report* of this Station for 1940, pp. 83-6.

As Grey Mould infects so many different kinds of plants, efforts to eliminate it from any particular field or plantation would appear to be hopeless. Attempts however to reduce its ravages should be made along the lines suggested by the observations here recorded. Crops that admit of clean cultivation should be kept free from weeds so far as it is possible ; this applies to bush fruit, hops, field beans, and vegetables. If a " cover-crop " is required, for producing humus in apple, pear, and plum orchards, the growth of promiscuous weeds should be discouraged by sowing a recognized cover-crop seed mixture.

Summary.—In 1941 Grey Mould, *Botrytis cinerea* was prevalent at two periods, in the first fortnight of June, and in the first half of autumn. It was found on many cultivated plants and also on a number of weeds, and was particularly abundant on the flower heads (capitula) of species of plants of the family Compositae.

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ENTOMOLOGY

NOTES ON SOME INTERESTING INSECTS OBSERVED IN 1941

By A. M. MASSEE

1. Cherry Fruit Moth (*Argyresthia nitidella* Fab.). The Cherry Fruit Moth is probably far more widespread in Kent than many cherry growers are aware, and this view is supported by the number of enquiries which have been received recently. It has been reported in 1941 from Chartham, East Farleigh, Brenchley and Kingsdown, near Wrotham.

The Cherry Fruit Moth does not seem to persist every year in the same orchard, indeed its very irregular appearance makes it very difficult for the grower to anticipate an infestation, and frequently a great deal of injury is done before the cause of the trouble is detected.

The Cherry Fruit Moth is on the wing in June and July, and lays its eggs under the bud scales towards the end of the latter month. Most of the eggs hatch out in the autumn, but a few remain in the egg state until the spring. On hatching most of the caterpillars hibernate in a silken case until the spring, but those which hatch in the spring bore straight into the buds. As soon as the fruitlets begin to develop they become infested, and it has been observed that one caterpillar will enter several fruits. The caterpillar is fully fed by the end of May ; it drops to the ground by means of a silken thread, and forms its chrysalis in the soil.

A tar distillate winter wash applied in December certainly tends to reduce this pest, but a good deal more of its life-cycle must be worked out before a complete control can be obtained.

One grower claims to have applied an atomized pyrethrum spray just after the blossom period with considerable success, but this experiment will need to be repeated before a general recommendation can be made.

2. Pale Brindled Beauty (*Apocheima pedaria* Fabr.).—Wingless females of the Pale Brindled Beauty moth were found in numbers on the trunks and branches of bush apple trees in a cultivated plantation at East Malling in February and March. The males (with fully developed wings) were present also, but were not as numerous.

The natural host plants of this insect are the oak and the whitethorn, but it has been recorded on many other trees as well, and there are records of its occurrence on cultivated fruits.

An inspection of the plantation was made in April and several caterpillars of the Pale Brindled Beauty were found feeding on the opening buds ; it seems probable, therefore, that the moths noted earlier in the year had deposited their eggs upon the trees.

The caterpillar is dull reddish-brown, and marked by red mottlings. The head is notched and is greyish-brown. It is a true looper caterpillar and attains a length of over half an inch.

Although this insect occurs commonly in the district each year it has not been noted on fruit before at East Malling, but it is abundant on oak in the surrounding woodlands.

3. Currant Shoot Borer (*Lampronia capitella* Cl.).—Early in April, 1940, a very severe infestation of the Currant Shoot Borer was noted at Southfleet. The outbreak occurred in a nursery where several varieties of red currant were being propagated. Curiously enough the outbreak was confined to two varieties, Red Versailles and Skinner's Early. Several other varieties growing in adjacent rows in the same nursery bed were not attacked.

The caterpillar passes the winter within a cocoon which is attached to a shoot. It becomes active again in the spring and bores into a bud or shoot. It frequently tunnels up the shoot causing it to flag and eventually die. The chrysalis stage is reached by the end of April or early May, and the adult emerges during the latter part of the month. Each of the infested bushes was cut down at the end of April and the shoots burned on the spot. This drastic treatment proved well worth while, since no further outbreaks were detected in the nursery bed later in the same season.

4. Caterpillars of the Winter Moth Group.—It is well-known that outbreaks of certain insect pests occur in cycles, and amongst insects contained in this category are those of the Winter Moth group. During the spring of 1939 these looper caterpillars were troublesome in many orchards in the Malling district, but the routine application of sprays kept them in check. In 1940 the infestations were more severe, and additional sprays were applied in many orchards. The infestations in the spring of 1941 were very bad indeed, and there is little doubt that the prolonged cold winds, the frosts, and the unkindly weather generally added materially to the severity of the outbreaks. Spraying at times proved difficult if not impossible, meanwhile the caterpillars were steadily developing and were devouring more and more foliage, not to mention the young fruitlets, which the larvae prefer to the foliage in their later stages of development.

The degree of attack varied considerably in different orchards, but in those where the spraying appliances were inadequate partial defoliation was general.

Several cherry orchards in the East Malling district received three applications of lead arsenate within a month, but even so the amount of defoliation was considerable. Two unsprayed cherry orchards were completely defoliated. From one of these neglected orchards the caterpillars migrated over the hedge into a neighbouring orchard and partially defoliated several rows of cherry trees. The fact that this latter orchard had been well-cared for and sprayed to prevent an outbreak of caterpillar shows how necessary it is to tackle the question of the derelict orchard.

5. Comma Butterfly (*Polygonia c-album* L.).—Twenty years ago the Comma Butterfly was common in the hop gardens of Worcestershire and Herefordshire, but it had not been noted in Kentish hop gardens for very many years until 1940 and 1941. A hundred years ago it was regarded as a pest in many hop gardens, and it was frequently referred to in the treatises written on hops about that period.

The Comma Butterfly is now more common in the Maidstone district than for many years past, and it is of interest to record the caterpillar feeding on the foliage of hop in several gardens. Specimens have been received from Goudhurst and Paddock Wood, thus the species seems to be re-establishing itself over a wide area of Kent. This very beautiful butterfly is not regarded as a pest, and it is in fact one of the delights of the countryside in the autumn months.

6. Hop Leaf Miner (*Agromyza frontalis* Mg.).—Several enquiries concerning hop foliage being injured by a species of leaf-mining insect have been received during the year. Growers have brought in material from the Paddock Wood district and the writer found further examples of injury on wild and on cultivated hops at Ditton, Kent.

The damage is very similar in appearance to that caused by the celery fly or the turnip fly, but the tunnels made in the tissue of the hop leaves are caused by a distinct species of fly called *Agromyza frontalis* Mg. The maggot of the fly tunnels into the tissue of the leaves in July and August, and by the end of the latter month the galleries are completed and no further injury results. They cause, however, little or no harm.

7. Social Pear Sawfly (*Neurotoma flaviventris* Retz.).—The Social Pear Sawfly was far more common in the Maidstone district in 1941 than for many years past. It is a curious insect which seems to disappear entirely for several seasons, and then suddenly turns up again without any apparent reason.

The caterpillar is orange-red with a pale brown stripe down each side of its body. The caterpillars live in colonies in tents made by them on the shoots and leaves. They are very repulsive creatures and it is fortunate they are not more numerous. Several colonies were found on young pear trees at the Research Station, but they did not cause any serious damage.

The tents containing the caterpillars should be removed and destroyed directly they are detected in July.

8. Hop Flea Beetle (*Psylliodes attenuata* Koch).—The Hop Flea Beetle is probably more common on hop in the Malling district than elsewhere in Kent, and large numbers of adult beetles may be seen feeding on the tender leaves in May and June. The degree of damage caused by these flea beetles depends upon the weather conditions prevailing in May and June. If the bines are growing rapidly, little harm is caused ; but should the growth be checked by adverse conditions the damage may be very considerable.

Although it is usual to find flea beetles in the hop gardens from early May until October, they are most numerous in the months of May and June, their numbers increasing again in September when a new generation of beetles has hatched out.

The Hop Flea Beetle did not cause much damage to the bines in May or June at East Malling in 1941, but abnormal quantities of beetles were still feeding on the young leaves in August, and in a garden of newly planted hops the damage was severe. The beetles feed not only on the foliage, but also on the developing hop-cones causing them to grow in a stunted, mis-shapen manner. Damage of a similar nature was noticed in a garden at Paddock Wood.

At hop picking time in September the adult beetles are commonly found sheltering in the fully developed cones, where they are especially common in the early mornings, and it seems likely that they go there in the evenings to seek refuge for the night.

9. Blister Beetle (*Lytta vesicatoria* L.).—Although the Blister Beetle is not associated with fruit it is of interest to record the occurrence of a swarm of these oil beetles alighting and feeding upon a privet hedge surrounding the garden of a farmhouse at Stourmouth, near Canterbury, Kent. This is the second record of this beetle at Stourmouth in the last six years.

The beetles were present in very large numbers, and since they emit a very pungent smell, which is most pronounced when they take to the wing on warm, sunny days, much annoyance was caused to the household. The swarm appeared in the middle of July and persisted for some days.

The beetle lays yellow, cylindrical eggs in a mass on the bare ground ; the grubs on hatching are predaceous, and are associated with certain kinds of bees.

The adult beetle is a very beautiful insect, the wing cases being a brilliant metallic green. Coppery coloured specimens sometimes occur with the type form.

10. Hop Frog Hopper (*Euacanthus interruptus* L.).—Reference was made to the Hop Frog Hopper in these notes last year, when it was stated that an unusual infestation occurred in a hop garden near East Malling.

This year the frog hopper turned up again in the same garden in May, but proved to be more numerous and to cause more injury than was the case last year. In some parts of the garden the adult hoppers still persisted in the middle of August, and the injury they caused to the bines was considerable. In the areas where the hoppers were most numerous the growth was checked materially, and could be detected quite readily by the stunted growths and the sickly appearance of the hills. The grower estimated that the crop was reduced by from one to two cwt. per acre as the result of frog hopper attack. Other gardens in the neighbourhood were not infested by this insect.

11. Migration of Hop-Damson Aphis (*Phorodon humuli* Schr.).—It is a well-established fact that the Hop Damson Aphis migrates from whitethorn and damson in the spring, and spends the summer months feeding on the hop, returning again to its winter hosts in the autumn. It has been noted in some seasons that the migratory period extends for several days, as, for example, in 1939, when winged forms were flying from damson to hop for a period of eight days.

On Friday, 3rd October, 1941, at 5.20 p.m. (summer time) dense clouds of aphides were flying along Easterfields Lane, East Malling. The great swarms of aphides were mainly confined to the area between the two hawthorn hedges of the narrow roadway, and extended ten or eleven feet into the air. This unusual swarm of aphides covered a distance of about a quarter of a mile, and their numbers were such that it was almost impossible to ride through them on a bicycle. Although a good many aphides were still flying in the lane at 5.45 p.m. they had all disappeared by 6.30 p.m. Large numbers of the aphides were collected and in every case the species proved to be the Hop-Damson Aphis (*Phorodon humuli* Schr.).

Such a phenomenon as that described above must only occur on rare occasions, and it would be of very great interest to learn where the aphides came from and why they all decided to migrate at one time. There are no hops in the immediate vicinity, and they did not seem to be interested in a large plum orchard just over the hedge.

12. Flat Bug (*Aneurus laevis* Fabr.).—This hemipterous insect, a sub-cortical species which is associated with many kinds of trees, occurs commonly under the bark of partially decayed oaks.

An eighty-year-old cider orchard at Edenbridge was visited in March and found to be in a derelict condition. The trees had never been sprayed, were covered with lichen, and had much dead wood.

Some of the bark was loose and on being removed large colonies of the Flat Bug were revealed. The insect was present in all stages and it was evident that it had been breeding there for some years. It is not a species of economic interest but its presence on apple seems worth recording.

13. Lygus on Pear (*Lygus pabulinus* L.).—Accounts are received most years from various parts of Kent of pears being attacked by the Lygus Bug. Although pears are known to be subject to attack by the Lygus Bug it is not wise to assume this insect is the cause unless the bug is actually seen causing the injury.

In 1940 Lygus injury to pear fruits was reported by a grower at Hoo, near Rochester. Another outbreak occurred the following June and the insect responsible proved to be the Lygus Bug. The outbreak was quite typical. Black currants were growing amongst the pears, and there is little doubt that the capsid bugs migrated from the currants to the pears towards the end of June. The infestation on the currants earlier in the season had been very severe. The Lygus did not appear to feed on the pear foliage but seemed to concentrate on the developing fruitlets. The damage was very characteristic. The fruit surface was punctured causing little irregular pits to develop. Later on the fruits became irregular in shape and very distorted, and corky patches developed on some of them.

A similar attack occurred at Faversham in the same pear plantation which had suffered ten years ago. The remedy is simple. Either remove the source of infestation by grubbing the currants, or control the Lygus by spraying with a petroleum or similar winter wash.

14. Apple Sucker (*Psyllia mali* Schr.).—One rarely finds the Apple Sucker in the main fruit growing areas of Kent since the introduction of tar distillate winter washes some eighteen years ago. Yet it is still abundant in some of the small orchards in outlying districts, and on farms where fruit is a secondary consideration, and the home orchard is left to fend for itself.

Apple Sucker is particularly prevalent in the Edenbridge district, and it is obvious that many of the orchards in that district fail to bear fruit because of the damage caused by this pest alone.

It is realized that difficulties arise when there is no spraying equipment on the farm, but some effort should be made to eradicate this pest when the maximum crop of apples is desired—whatever the variety may be—in these difficult times.

15. Pear Sucker (*Psyllia pyricola* Först.).—The Pear Sucker differs from the Apple Sucker in that it hibernates as an adult and has three broods annually, whereas the Apple Sucker passes the winter in the egg state and has but one brood each year. The Pear Sucker is not a very common insect in most seasons, but it can usually be found if a careful search is made on the undersurfaces of the leaves. The young Suckers live singly, and mainly occur near the mid-rib.

A severe infestation was noted some fifteen years ago in a pear plantation at Belvedere, North Kent. Since that time, however, it has not been noted again until recently. In 1940 the Pear Sucker was found in some numbers on pear at the Research Station. Adults were common in the autumn and remained until the trees became defoliated. Adults were again common in 1941 and observations show that they are breeding on the trees.

16. Vine Gall Mite (*Phytoptus vitis* (Land.) Nal.).—A number of vine leaves were sent to East Malling in the summers of 1940 and 1941 from a nursery at Offenham, near Evesham, Worcestershire; they were suspected of being infested with a species of mite.* The material arrived too late in the season in 1940 for an accurate diagnosis to be made, but the leaves sent the following year arrived in very good condition, and a thorough examination revealed the presence of large numbers of eriophyid mites among the hairs of the undersurfaces of the leaves. The mite proved to be the Vine Blister Mite (*Phytoptus vitis* (Land.) Nal.) a species which is well-known on the Continent. In this country it has been recorded only twice previously; once by the late George Massee who recorded it from Reading in 1910, and later on by the writer who found it infesting vines growing under glass at Tunbridge Wells in 1928.

The mites live and feed among the hairs on the undersurfaces of the leaves. The irritation caused by the feeding produces little blisters on the upper surface, and conspicuous leaf wrinkling occurs when the infestation is bad. The mites hibernate on the canes of the vine. The variety chiefly affected at Offenham is Black Hamburg.

17. A Little-known Earwig on Fruit.—An uncommon species of earwig known by the scientific name of *Apterygida albipennis* Meg. has been found in the autumn months of the past two years among the foliage of apple in the plantations at East Malling. The earwig is not a harmful species since it does not attack the trees or fruit, and a more likely explanation for their presence is that they ascend the trees on suitable days to take advantage of the warm autumn sun.

The earwig is said to be associated with hop gardens, but there is little evidence in support of this view. Many years ago, however, hops were grown on the sites where the earwigs were found at East Malling recently.

* The writer is indebted to Dr. C. L. Walton and Mr. S. H. Bennett for sending the material.

There are only a few authentic records of the occurence of the earwig in this country, and Kent seems to be its headquarters.

Summary.—Notes are given on seventeen insect pests of fruit trees and hops observed in 1941.

A MEANS OF PREVENTING OUTBREAKS OF CERTAIN PESTS IN EXPERIMENTAL GREENHOUSES

By A. M. MASSEE

The research worker experimenting with plants in insect-proof houses, and the practical grower cultivating such crops as tomatoes, cucumbers, and even choice flowers under glasshouse conditions, are both constantly confronted with the problem of combating numerous pests which may infest and destroy their plants with little or no warning.

Amongst the more important pests are the greenhouse red spider and the numerous species of aphides which infest glasshouse crops.

Such pests may be partially kept in check by employing rigorous hygienic measures such as to clean out completely the house and to sterilize the soil directly the crop has been gathered, to make certain that proper ventilation is maintained, and to insist on routine " damping-down " of the house each morning and evening. In addition to these precautions it is often necessary to fumigate the house with a nicotine preparation, or some other fumigant, immediately these pests are detected. It is hardly necessary to emphasize that when such pests as red spider become established in a greenhouse, it is almost impossible to eradicate them, and the plant growth may suffer considerably, with resulting lack of crop. The reason for this is obvious. The various stages of the mite overlap ; thus adults, immature stages, and eggs are all present on the plants at the same time, and the egg stage is almost impossible to destroy with the present insecticides and fumigants available. In consequence the pest persists throughout the season.

A sudden outbreak of red spider on plants growing under apparently insect-proof conditions is constantly a source of worry to the research worker who is endeavouring to grow plants free of insect infestations, and not infrequently experiments have to be abandoned on account of the presence of this pest.

A simple means of preventing infestations by these troublesome pests has been adopted as a matter of routine at the Research Station.

The procedure is as follows. One and a half lb. of ground derris powder and 2 lb. of soft soap are added to each hundred gallons of water in the tank in the house, used for " damping-down " the plants each morning, midday and evening. An " Eclipse " hand-machine is used to facilitate " damping down " the plants, and the water in the tank is well stirred before the syringing begins.

When the tank is about half empty a fresh supply of derris and soap is added, and the tank filled with water. The amount of derris and soap added for this and subsequent mixings is reduced to one-eighth of the original quantity, namely, derris 3 oz. and soap 4 oz. Provided the plants are thoroughly " damped down " each morning, midday and evening, and the water in the tank is well mixed before the syringing is done, the reduced amount of derris is sufficient to prevent red spider and aphides establishing themselves on the plants. This is doubtless due to the accumulation of derris on the foliage, which results from the regular " damping down " of the plants.

This measure has been carried out in the experimental greenhouses and insect-proof houses, where insects are not being reared, at the Research Station from the beginning of May until the end of the autumn, the plants consisting mainly of hops, strawberries, raspberries, and black currants, and all have remained entirely free from insect and mite attack. A thin deposit of derris accumulates on the foliage of the plants, but this is readily removed by submerging the plants in clear water.

Unfortunately this treatment cannot be recommended for use in the insectary, where tests are being made with insects as possible vectors of virus diseases. It should prove invaluable, however, in the virus house when grafting experiments are being made, and where insects must be kept completely out of the picture.

Finally, it may be mentioned that a number of hop plants growing in pots, and severely infested with red spider were transferred to a greenhouse where the derris " damping down " treatment was in progress. Within two weeks the red spider population had been completely destroyed, and none of the red spiders infested the plant material already growing in the house.

Summary.—Details are given of a method used for keeping plants growing under greenhouse and insect-proof conditions free from red spider and aphides, by adding a derris preparation to the water used for " damping down " the plants each morning, midday, and evening.

Section IV

BULLETINS FOR FRUITGROWERS

POMOLOGY

RASPBERRY PLANTING : SOME NOTES ON VARIETIES

By N. H. GRUBB

Though the number of raspberry varieties now planted commercially is not large, the choice is by no means easy. Though naturally in war-time the primary call for small fruit is for jam and processing it must be remembered that raspberries planted in the winter of 1942-3 will yield their first good crop in 1945, and should continue yielding for several years thereafter. Whilst it would be rash to forecast the sort of markets for which growers will then be producing, one could hardly consider it wise (except perhaps in districts where raspberries are grown mainly for jam) to plant largely a variety like Baumforth Seedling " A " for instance, which, though a very heavy cropper, is fit *only* for jam.

It is hoped that the following notes will help prospective planters in their choice. The varieties named are not all as yet obtainable in large quantity ; but they are thought nevertheless to be worthy of mention. Except in the case of Norfolk Giant, there is little difference in their season of ripening. The writer does not know of a good early variety for commercial planting, though one or two seedlings raised at East Malling give some promise in this direction.

Lloyd George is generally found to be less vigorous than formerly. Whilst it is still amongst the best varieties in the north of England, and Scotland, in the south it can no longer be unreservedly recommended. Except where it is known to do well, it would be unwise to risk a large planting without a preliminary trial lasting at least four years. Mosaic rogued stocks are available ; but even these frequently fail to retain their vigour for more than two or three years after planting. Since it is known that this variety can be infected with a certain category of mosaic virus without showing symptoms, it is possible that the loss of vigour may be due in part at least to virus.

Norfolk Giant is probably now more widely planted than any other variety. Prospective planters should realize that it is late ripening and hence would be useless for an early market. Mosaic-free stocks are available, and are believed to be as nearly free from virus as those of any variety. Norfolk Giant does, however, sometimes show mosaic clearly ; it is then usually much less vigorous than when healthy. Whilst mosaic can only be recognized by the leaf symptoms in summer, if in winter the plants are found to be uniformly vigorous there is a good chance that the proportion infected will be low. Partly infected stocks can usually be recognized by the mixture of strong and weak plants.

Brocket Hall was found some years ago to show promise in the National Fruit Trials at Wisley ; it has recently been reported as cropping better than any other variety in a trial in Cornwall. Unfortunately it has not succeeded at East Malling. The variety appears to be rather rapidly infected with mosaic ; it is impossible to estimate from East Malling experience how much it deteriorates when infected.

The following four varieties are planted commercially in certain districts, but cannot be generally recommended for planting without a preliminary trial except where they are known to do well. So far as is known they always show at least slight mosaic symptoms, but they are believed to be seldom badly injured by the disease. They should not be planted near mosaic free strains of the above varieties.

Pyne's Royal in favourable conditions produces a good crop of fruit of the largest size. Its commonest fault is the production of too few canes for a good crop.

Pyne's Imperial is very similar to Royal in growth, often with the same fault ; its fruit is definitely as large, and improved in shape and colour.

Red Cross though not so large fruited as Royal and Imperial, usually produces a heavier crop. The canes have a rather spreading habit, and in some soils are more thorny than those of most varieties.

Laxton's Bountiful is commonly planted in East Sussex, where it grows and crops satisfactorily. It would probably be worth a trial in other districts.

Several other varieties might also be considered, at least for trial.

Matchless gave considerable promise some years ago in the National Fruit Trials. At East Malling it has grown and cropped well ; the fruit is firm enough and of good colour, but of no more than average size. Its mosaic reaction is little known ; at East Malling it has not so far been seriously affected.

Preussen has grown and cropped well at East Malling. Its fruit is large and of fine colour and flavour, but apt in certain soils to be too soft for anything but jam. The plants are sometimes short lived, and the rows then become gappy. Its relation to virus is not well understood ; it can act as a symptomless carrier, but frequently shows mosaic clearly, and is often apparently much dwarfed by it.

Newburgh is a recent introduction from the United States. It gave promise of being one of the best varieties ever grown in England, but has recently shown a rather extreme susceptibility to cane-blight (caused by a soil fungus, *Leptosphaeria Coniothyrium*) which may make it useless. For this disease no satisfactory control is yet known. It has not shown any mosaic at East Malling ; it has recently been found to be a potential symptomless carrier of virus.

Hercules (introduced by Messrs. Harraway of Warminster) is a promising new variety. It usually grows well, but in some seasons has not produced enough canes for a full crop. Its fruit is good in size, shape, firmness and colour, but may be unsuitable for canning on account of a large " plug ".

St. Walfried is a promising new Dutch variety. In growth it is rather of the Lloyd George type, with heavy foliage ; its fruit, though not so long in shape as that of Lloyd George, becomes almost as dark coloured when fully ripe. It is understood that the raiser found it became rapidly infected with mosaic, which made it useless ; so far as the writer knows this has not yet happened in England or Scotland.

Doncaster is a new Eastern Counties variety much like Lloyd George in growth and general appearance. It has not succeeded at East Malling, but is said to do well near Wisbech. Little is known of its virus relationship.

Summary. Raspberry varieties recommended for planting are briefly described.

HOW TO IMPROVE BLACK CURRANT PLANTATIONS

By J. AMOS, R. G. HATTON and T. N. HOBLYN

RECENT surveys made at the request of the War Agricultural Executive Committees have revealed some striking examples of poor condition and low yields in many black currant plantations. In view of the emphasis now being placed on the dietetic value of this fruit, this seems a good time to recall some of the results of our early experiments in black currant growing to see how far these have been confirmed or qualified by later results, and to indicate what those results suggest for effecting improvement in the productiveness of black currant plantations generally.

Varieties.—For the last 20 years we have endeavoured to maintain cropping bushes of the original four groups of black currants, Boskoop Giant, Seabrook's Black, Goliath*, and Baldwin. The observations made over this long period, which has included examples of most kinds of climatic conditions to be experienced in the south-east of England, have served to emphasize the importance of selecting varieties suitable both for particular environments and for market requirements. Thus under our conditions, since 1922, Baldwin, our most reliable variety, has averaged 37 cwt. per acre annually, in contrast with Boskoop Giant, our most uncertain cropper, at slightly under a ton (indeed, in an open situation, Boskoop Giant has only once yielded more than 8 cwt. in eight years). Goliath has given 29 cwt. and Seabrooks 26½ cwt. Thus the results of the earliest variety trials, published seventeen years ago, have been largely confirmed. In these first trials the bushes were typical of those then to be found in commerce with the attendant drawbacks of Big Bud and Reversion. By regular roguing of the plantations from which cuttings were taken, and by careful weeding out of Reverted plants in the cutting beds, maintained for two years in order to make doubly sure of obtaining none but clean plants, a stock of healthy clonal plants has been built up, so that, apart from occasional sporadic outbreaks, Reversion has not materially affected the cropping issue ; nor has Big Bud, once the means of control were known, become of importance. These facts have much to do with the comparatively high level of performance which has been maintained.

Looking over the twenty years records, Baldwin's highest crop was 4 tons per acre in 1931, and its lowest crops were 6 cwt. per acre in 1936 and 1938. In both of these years Goliath and

* This group includes Edina and Victoria.

Seabrooks gave double or treble the crop. Again, there was actually one season, 1924, in which Boskoop Giant proved the heaviest cropping variety, yielding nearly 3½ tons per acre, and two others, 1932 and 1934, in which this variety gave 50 cwt. This suggests that growers would be wise to plant more than one variety to meet the very variable conditions which in particular seasons can so modify the general trend. In addition, in normal times, the relative prices of early, mid-season and late varieties from any particular locality may well be a determining factor in deciding what varieties to plant.

Since the National Fruit Trials were inaugurated in 1923, it has been the function of the Royal Horticultural Society to classify and test new introductions. Therefore, all these varieties have not been grown extensively here. Nevertheless this paper would not be complete without reference to the very few, such as Westwick Choice, Mendip Cross, Cotswold Cross, Davison's Eight and Wellington Triple X, which have found their way into commerce. The last of these, since it was raised here, has been included in our trials for many years and has proved a very heavy cropper, achieving 4½ tons per acre and over in some seasons. Here, on our Malling sandy loam, planted at the same number of plants per acre, it has generally outcropped Baldwin; but the latter smaller growing variety may be planted closer in the rows and can by this means be made to give the heavier acreage yields.

To sum up our knowledge of the chief varieties grown in commerce to-day, whilst Baldwin does exceedingly well on good soils and with generous treatment, it generally makes insufficient growth on both light sands and heavy clays. On the other hand Wellington Triple X is so vigorous that it crops heavily under both these conditions. If early fruit is required and shelter and moisture conditions are satisfactory, there is no doubt that Boskoop Giant holds the field. Whilst the Goliath group are not only sulphur-shy, but seem very susceptible to adverse soil conditions, they usually produce by far the largest and sweetest fruits. Goliath has been rather less susceptible to climatic changes. Davison's Eight is an early fruiting sub-type of this group. Of the French group, Seabrook's Black, the most widely grown, is a hardy variety, but again requires shelter to give its best results. Of the newer introductions, Wellington Triple X and Mendip Cross are very similar, and whilst in growth they more resemble the Boskoop group, though with a greater tendency to spread, they seem to set their fruit, which ripens midseason, more freely. Westwick Choice is obviously a close relative of Baldwin and slightly later in season.

Climatic conditions.—One of the most important of our early researches in black currant growing was that, apart from the virus disease Reversion, the principal cause of failure to crop was the "Running off" of the young fruits towards the end of the truss due to inefficient fertilization, since the structure of the flowers on some varieties made self pollination impossible. The damage to blossom by frost was of course realized to be a further cause, but was easily distinguishable. Our experiments showed that where insects could move freely in sheltered positions, "Running off" seldom occurred. We are very subject to cold winds here in spring and, looking over the twenty years records, it is informative to note that the heaviest crops of all our black currant varieties were produced at the time when they were interplanted between fruit trees, and that since we have brought them right into the open, we have never had such big crops. In view of the different nutritional and spray control requirements of top and soft fruits, it must not be thought that we are advocating, under normal conditions, a return to the practice of interplanting, but we are merely stressing the importance of shelter, which can be obtained in other ways.

Apart from the season of 1928, in the first ten years 1922-31, climatic conditions never reduced the crop of Baldwin below a ton to the acre, and rarely below 30 cwt. By contrast, in the second ten year period, this variety gave less than a ton in four seasons, 1933, 1936, 1938 and 1941.

In all of these seasons frost reduced the black currant crop and Baldwin, which normally flowers about a week earlier than the other three, suffered most in three of them. Indeed the later flowering varieties Goliath and Seabrooks cropped at round about a ton per acre or more. It is worth noting that the frost *just before* blossoming in 1936 did more damage to black currants than the much more generally damaging frost in 1935, which occurred after they had completed their blossom season. In 1936 the early flowering Baldwin suffered most, while in 1935 it was least affected.

In the four years 1933, 1936, 1938 and 1941 cold north-east winds prevailed during the blossom season and apparently had nearly or quite as much effect in reducing the crop as actual frosts. Indeed, as we write, we are able to add that, in 1942, no severe frosts were recorded at blossom time, yet such was the effect of the cold north-east winds, that Boskoop, Seabrooks and Goliath all "ran off" very badly. Baldwin, on the other hand, was hardly affected and produced a crop of 2½ tons to the acre. In another season, 1940, the crop was reduced by a high percentage of abortive blossom which was deemed to be due to winter injury from the severe January weather of that year.

Manurial and Cultural Treatment.—Our surveys seem to show that there is a general tendency to leave a considerable amount of unprofitable old wood in the bushes. In pruning experiments

here, unpruned bushes did not yield less than pruned bushes, but the fruit was smaller and consequently more expensive to pick. At the present time it is considered that at least half the old branches should be either shortened severely or cut right out at the base annually, if an adequate supply of young cropping wood is to be maintained.

In the days when we used to produce 3 and 4 tons per acre of black currants, it must be remembered that bulky organic manures were more readily and reasonably obtainable, and that in recent years more reliance has had to be placed upon purely artificial fertilizers. On soils of a low moisture-retaining capacity, dung is probably an essential to heavy cropping, supplemented by nitrogenous fertilizers preferably of an organic nature. On some soils, and particularly for members of the Goliath group, potash is necessary, and should be given if obtainable.

Light pruning and less generous manuring combined with a cycle of unpropitious springs have almost certainly all contributed to lower yields. However, it is worth noting that, starting here with clonal disease-free bushes in 1932, a two acre plantation of Baldwin and Wellington Triple X, regularly rogued for Reversion, has yielded over 2½ tons per acre in its tenth year, despite light pruning and not over generous manuring.

Experiments in distance of planting have not produced any dramatic differences in yield per acre. Bushes of the four varieties Boskoop, Seabrooks, Goliath and Baldwin, planted 7 ft. 6 in. by 4 ft., averaged annually about 2 cwt. per acre more than those planted at 7 ft. 6 in. by 6 ft., over a period of seven years. When the bushes were young the advantage of close planting was rather greater and, in addition, the growth of weeds was checked. On the whole, however, the difference is small compared with the extra number of bushes planted per acre, the wider planted bushes producing more fruit to the bush.

Pests and Diseases.—In many plantations Big Bud and Reversion are again all too obvious and are spreading very rapidly. It will be recalled that the Big Bud mite was shown to be a vector of the Reversion disease and, since the former could be kept under control by a routine 2 per cent. lime-sulphur spray just before the blossom begins to open, the spread of the latter could also be checked. It must be remembered, however, that practically all varieties showing Goliath characteristics, including Davison's Eight, are susceptible to sulphur damage, which is a definite disadvantage to the use of these varieties under most conditions. It still remains to be proved whether there are other vectors of this disease.

The very rapid increase of the green capsid bug (*Lygus pabulinus*) requires more attention than it is receiving. Control by dinitrocresol or petroleum spray in February or early March is recommended. A routine 5 per cent. tar oil spray in December or January for aphis control is also necessary unless a D.N.C. spray is used. In some localities and some seasons Leaf Spot disease (*Gloeosporium Ribis*) causes severe defoliation in June or early July with a consequent withering of the fruit, the Baldwin group being particularly susceptible. In such an event a Bordeaux or other copper spray should be applied immediately after the fruit is picked. All these troubles frequently start in the nursery and every grower should avail himself of the Ministry of Agriculture's certification scheme, especially in these times when the maximum performance is required from every individual bush.

Renovation of existing Plantations.—The considerations so far outlined apply for the most part to the establishment and maintenance of young plantings. If, however, the cropping of an existing plantation compares unfavourably with the not very high standard we have been able to maintain, how far can this be remedied? The original planting may be fundamentally wrong; for example Boskoop Giant in an exposed situation, or any variety in a frost pocket. The number of Reverted bushes may be so large that no amount of roguing will be of any help. In either of these instances, it is better to grub and start again. But, given suitable varieties and location, much can be done to improve an existing plantation, if diseases are not too firmly established. First, it is essential to control pests with the regular spray programme. Then, centres from which Reversion is spreading must be rooted out. If growth of young wood is poor, generous manuring together with a drastic cutting out of old unproductive branches may do much to restore vigorous growth. On such growth Capsid attack must be watched for. If you are in any doubt as to what is wrong, or you are not sure what Reversion looks like, bring in an expert to inspect your plantation and train your foreman to distinguish Reverted from normal foliage. The symptoms were fully described in 1927* and we are fortunate still to have a good stock of reprints of the paper available.

Summary.—The selection of varieties suited to environmental conditions and market requirements is of first importance. Whatever the varieties chosen, it is essential to plant only bushes certified true to name and free from disease. Cuttings for propagation should only be taken from clean bushes in plantations which are annually rogued for Reversion and which receive a routine lime-sulphur spray for the control of the Big Bud mite, its vector. Cutting beds should be well

* J. Amos and R. G. Hatton (1927). Reversion in Black Currants, I and II. *J. Pomol.* **6**, 167 and 295. (Reprints Price 8d. to Members.)

spaced to facilitate further roguing. Two-year-old plants are preferable to one-year-old, since, if a cutting is taken inadvertantly from a Reverted bush, the disease is not always obvious the first year. If, under wartime conditions, one-year-old bushes must be used or cuttings planted directly where they are to fruit, these must be taken from parent bushes known to be free from Reversion.

Soil for black currants should have a good moisture-holding capacity; apart from this, they may be grown successfully on a wide range of soils.

A position sheltered from north-east winds is to be preferred. Alternatively, shelter belts are worth consideration.

The distance of planting must depend upon soil and the varieties chosen. Ample space should be left between the rows for cultivation and the bushes planted rather closer in the rows. Generous nitrogenous manuring is desirable and dung should be applied if obtainable. Potash is necessary for varieties of the Goliath group on some soils. Pruning should be sufficiently hard to maintain a good supply of young cropping wood. In order to keep plantations free from Big Bud and Reversion a routine 2 per cent. lime-sulphur wash just before the blossoms open, except for varieties of the Goliath group, and regular roguing are strongly recommended. The control of the Lygus capsid bug by a dinitrocresol or tar petroleum wash is also urged.

STRAWBERRIES:

MAKING THE MOST OF A LIMITED ACREAGE

By W. S. ROGERS

THE strawberry, before the war, second only to the apple in its annual value, has had perforce to give way to a large extent to cereal and root crops, and a large decline in strawberry acreage has taken place. Nevertheless, strawberries have a value all their own. Not only are they among the most delectable of fruits, but they are the quickest cropping. Their unrivalled jam qualities are matched by their exceptional richness in vitamin C, comparable with citrus fruits (Zilva and Rogers, 1940), and they come at a time when other fruits are scarce.

Under present conditions, therefore, it is especially important to get the maximum yield per acre, while at the same time keeping the labour required to a minimum. The following notes, based on research and practical experience, suggest ways of doing this.

Photo E.M.R.S. C.294] *[from Rogers, 1939*

FIG. 1.

Royal Sovereign: Effect of Yellow-edge.
Y, Yellow-edge affected. H, Healthy.
Two originally healthy plants produced from the same parent in August, 1931. Y showed virus symptoms September, 1932. Photo taken May, 1933. In October, 1933 H also developed symptoms.

Obtaining good Runners.—The most important point is to plant runners of a good stock. The Ministry of Agriculture has already taken a most valuable step to assure this, by its order that all runners to be planted must either hold the Ministry of Agriculture's Certificate, or be approved by the local War Agricultural Executive Committee. This will automatically prevent the planting of poor and degenerate stocks, and should result in a great raising of the standard of production.

The questions of variety and cultural conditions are left to the choice of the grower. Here good advice can be very valuable.

Planning for Maintenance of Health.—The chief problem is how to avoid those virus diseases and insect pests which usually set a limit to the useful life of a plantation. *Yellow-edge* is the worst virus disease. It causes the leaves to become dwarfed and curled because the edge of the leaf does not grow so quickly as the middle. In Royal Sovereign the leaf edge becomes yellow, and the whole plant assumes a flattened appearance (see Figs. 1 and 2). *Crinkle* has a less drastic effect, but its severe form can be troublesome. This, as the name implies, causes a crinkling of the leaf, due to little pale spots, distributed over the leaf, which do not grow. The spots are yellowish at first, and later turn red (Fig. 2).

Photo E.M.R.S. P.42] *[from Harris, 1937*

FIG. 2.

Royal Sovereign leaves showing range of relative variation in emphasis of each virus symptom-type.
Leaves 1 and 2 (left). Yellow-edge predominates.
3 and 4 (centre). Equal Yellow-edge and Crinkle.
5 and 6 (right). Crinkle predominates.

These viruses persist like a poison and multiply in the plant, causing more or less rapid deterioration. Infected plants cannot be cured, but pass the virus to any runners that they produce, hence the only way to free a stock from virus is to destroy every plant that is infected. On a field scale—particularly in propagation beds—this is done by "roguing" at the times when the symptoms show best, usually in July and September.

The Strawberry Aphis (*Capitophorus fragariae* Theob.) is serious as the vector which carries the viruses from diseased to healthy plants, and the Strawberry Tarsonemid Mite (*Tarsonemus pallidus* Banks) can be troublesome in hot weather, for it not merely weakens plants, but makes it impossible to recognize and remove virus-infected plants. These virus and insect troubles, which between them can ruin a plantation within a season, have been fully described and illustrated by Harris (1933, 1937), King and Harris (1942), Massee (1935), and Massee and Greenslade (1941), and their papers should be consulted for further details.

For the grower, having already obtained good and approved runners, the first line of attack should be in methods of planning and hygiene in relation to the varieties chosen, and the location in which they are placed. Recent fruit surveys have shown that the value and importance of such measures are not yet fully realized.

Keep "virus-susceptible" and "carrier" varieties apart. Some important varieties are "virus susceptible," i.e. if infected, they show symptoms fairly rapidly and distinctly, though under certain

conditions these may not be visible at certain periods of the year. Infected plants of the "susceptible" class can be rogued fairly efficiently, and stocks maintained practically virus-free. Other varieties are "carriers", i.e. their virus-infected plants do not as a rule show distinct leaf symptoms at any time, but appear quite healthy. Such plants finally break down, but during their whole life they have been a potential source of infection for healthy virus-free plants. Therefore it is most important not to plant susceptible varieties near carrier varieties, which would very likely infect them within a short time.

The varieties which appear to be of greatest importance at present are Royal Sovereign, Huxley, Tardive de Leopold, Mme Lefebvre and Sir Joseph Paxton. Of these Huxley and Mme Lefebvre are virus carriers. Royal Sovereign and Paxton are "susceptibles", and Tardive de Leopold is intermediate. The varieties classed as "intermediate" show distinct symptoms only occasionally. Actually an almost complete series of grades of susceptibility is found, but for practical purposes all varieties which cannot be effectively rogued by field inspection, including the intermediate classes, should be treated as "carriers" (Rogers, King and Massee, 1939). Therefore it is safe to grow Royal Sovereign and Paxton together, but they should be kept well away from Huxley, Mme Lefebvre and Tardive de Leopold.

Very good stocks of Royal Sovereign are now obtainable. The original Malling clone of Royal Sovereign (Malling 35) cropped at 3 to 4 tons per acre, under good conditions, although containing mild Crinkle. The latest clone, Malling 40, is free from both Yellow-edge and Crinkle.

Huxley has a special value where bulk is desired; but care should be taken to get first class stocks, since in many stocks the progress of the virus is relatively far advanced, in which case the plants break down relatively quickly.

Tardive de Leopold, of course, needs a pollinator. Huxley is suitable for this, or, if desired, Royal Sovereign can be used; but the Tardives, with their pollinators, should be kept well away from the main Sovereign plantings.

Huxley and Mme Lefebvre can be grown together, well away from Sovereign. No exact distance can be quoted as safe. A hundred yards is better than nothing, but half a mile is better still. The only exception is where perfect control of the strawberry aphis, the natural vector of the viruses, can be obtained. Recently a new method of control by vaporized nicotine has been introduced (Massee and Greenslade, 1941); but under present conditions this is only likely to become available on a restricted scale. In any case planning for isolation is a cheap and simple precaution, well worth the extra trouble involved.

For ease of reference, these planting recommendations are given as a table, below.

Varieties which may be grown together.	Varieties which must *not* be grown together (unless perfect aphis control is obtainable).
Royal Sovereign and Sir Joseph Paxton.	Royal Sovereign and *Huxley*.
Huxley and *Tardive de Leopold*.	Royal Sovereign and *Madame Lefebvre*.
Huxley and *Madame Lefebvre*.	Royal Sovereign and *Tardive*. (Sovereign in bulk.)
Tardive de Leopold and Sovereign (Sovereign as pollinator only).	Paxton and *Huxley*.
	Paxton and *Lefebvre*.
	Paxton and *Tardive*.

Carriers shown by italics.

For the same reasons of avoidance of infection, new plantings should be kept as far as possible from old strawberry fields, where diseases and pests may have multiplied. The common practice of planting new runners immediately next to old strawberry beds definitely favours the rapid spread of disease.

The nicotine dip for runners. The strawberry aphis can easily be controlled on runners before planting, by the use of a dip consisting of nicotine 1 oz., soft soap 1 lb., water 12½ gallons. The plants can safely be immersed, roots and all, and this treatment is always a desirable safeguard.

If mite is present on the runners, the warm water treatment (Rogers, King and Massee, 1939) is the only good control method at present available. This also kills aphides, but should not be used unless mite is present, on account of its checking action on the plant.

Direct Cultural Measures for Increasing Crop.—*Distance of planting* has a large effect on crop weight. Trials at East Malling, comparing Royal Sovereign plants at 36, 18 and 9 inches respectively, in rows 36 inches apart, showed that the closest spaced plants gave the largest crop per acre—though the widest spaced plants gave the largest crop per plant. Now, when the acreage is artificially limited, relatively close planting should be worth while, notwithstanding the increased number of

plants required. The best distances will depend on variety, soil, and climatic conditions ; but for Royal Sovereign on medium loam in Kent, plants 12 inches apart in rows 30 inches apart would probably be a useful minimum. If spaced closer than this, a risk of heavy losses from Grey Mould (*Botrytis cinerea*) is run, and drought is also a danger. The strawberry rows should be arranged to run north and south, as this allows the sun to reach both sides of the rows, both lessening risk of moulds, and improving fruit ripening.

Time of Planting affects the vigour and cropping throughout the whole life of the plant. Provided the soil is moist enough and warm enough, the earlier planting is carried out the better is the result. It is thus well worth planning to enable planting to be done in autumn rather than in spring, wherever possible. Under Kent conditions mid-September to mid-November is usually satisfactory. Once the soil cools below about 45° F., little or no root is made, and if autumn planting is impossible it is desirable to wait till the soil warms up in February or March.

Deblossoming. Malling experiments have shown that, in most cases, plants that were deblossomed in the first season gave in the second season a crop much greater than the two seasons total of plants that were not deblossomed, quite apart from the saving in strawing and other costs. Wartime regulations may bring other factors into consideration, however. The fruit from " maiden " plants is usually early and of high quality, and if it can be sold as fresh dessert fruit it will probably be worth allowing the maiden plants to crop. If, on the other hand, all the fruit is destined for preserving purposes, it should pay to deblossom the plants in their first season.

Avoiding frost damage.—It is, of course, assumed that as far as possible low-lying areas that are subject to frosts will be avoided when planting ; but the work of Cornford (1938) and others gives rise to the suggestion that frost damage may be affected to some extent by the practice of strawing. Cornford showed that on a frosty night all objects tend to lose their heat by radiation. The earth acts as a storehouse of heat, and any insulating layer placed above it tends to keep in the heat and allow relatively greater cooling above the insulator. Therefore straw placed *above* the blossoms will keep them warmer, on a frosty night, but if placed *below* the blossoms it will allow them to cool more than they would if it were absent. The practical suggestion is therefore that if there is danger of frost the straw may well be laid *over* the plants at night, and be raked away during the day, but that it should not be tucked *under* the plants until frost is no longer expected. Such treatment will, of course, depend on the labour available, and its value has not yet been tested by controlled experiments. However, normal strawing practice with tucking in of the straw should clearly not be carried out too early.

Manuring.—The strawberry likes a good deep rich soil, and farmyard or other organic manure at 20-30 tons per acre before planting is desirable. Failing this, at Malling good results have been obtained with annual artificial manure dressings. Strawberries respond especially well to phosphatic dressings, particularly meat and bone meal, about 5 cwt. per acre, or alternatively superphosphate, 2½ cwt. plus sulphate of ammonia or nitrate of soda 1 to 2 cwt. If potash is lacking in the soil the equivalent of 1 cwt. sulphate of potash should be applied, where possible (Wallace, 1941).

Liming.—A survey of literature, made in response to various enquiries, on lime in relation to strawberry nutrition, showed much divergence of results. Some writers found lime beneficial, others considered it useless or harmful. Wallace (1941) concluded that the lime content of soil for fruit generally was of relatively little importance, except in extreme cases.

No experiments on liming strawberries have been carried out at East Malling for the good reason that the soil is already alkaline throughout, having a *p*H value between 7·5 and 8·0*. The fact that strawberries grow exceptionally well on this soil proves that soils rich in lime are not necessarily bad for strawberries.

Study of other work, however, suggests that the importance, for strawberries, of soil lime content lies mainly in its effect on availability of other nutrients. Truog (1938) found that in soils above *p*H 7·0 many of the minor elements such as iron, manganese, and zinc become less available, with bad effects, especially in soils deficient in organic matter. Thus in such soils liming would probably be harmful and good organic manure dressings are important. In soils below *p*H 6·5, however, phosphates became less available. Under such conditions dressings of phosphate would be important, and in any such soils containing much phosphate in unavailable form lime would probably do good. In more acid soils, say below *p*H 6·0, both lime and phosphate would appear desirable. But in general the main concern seems to be to maintain adequate supplies both of organic matter and of phosphates, rather than of lime.

Irrigation.—Where a water supply is cheaply available, useful crop increases can be obtained in dry seasons by artificial watering. This can be done by special spray devices, or, more cheaply, by running the water along furrows drawn beside the rows. The latter method is relatively wasteful

* The *p*H scale is a measure of soil acidity and hence of lime content. A *p*H of 4·5 indicates a very acid soil, *p*H 7·0 a neutral soil, and *p*H 8·5 a very alkaline soil.

of water, but is useful where a water supply is available by gravity feed from a mill pond or stream. The equivalent of ½ to 1 inch of rain (about 2 to 5 gallons per square yard) should be applied at each irrigation. The conditions under which irrigation is economic will vary with the soil, but if no rain has fallen for a week, following a fairly dry May, irrigation is most likely to give a good response.

For fuller details of these and other cultural measures, reference should be made to publications by Rogers, King and Massee (1939) and Oldham (1937).

Summary.—Methods are described of obtaining maximum production per acre, including selection of stock and variety, avoidance of virus diseases and pests, cultural policy and methods, manuring and irrigation. Isolation of susceptible from carrier varieties and new from old plantings is advocated. Closer planting, within limits, will raise crop per acre. Soil acidity and liming are discussed.

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GRAFTING ESTABLISHED FRUIT TREES

A WARTIME SOLUTION TO A WARTIME PROBLEM

By R. J. GARNER

In wartime the fruitgrower is naturally more interested in increasing the crop from existing trees than in planting new ones. Recent surveys have shown that many orchards, especially Bramley's Seedling, are not cropping as well as they might owing to lack of efficient cross-pollination. To increase the crop from such orchards is clearly a wartime problem of great urgency, and the practical solution of this problem appears to be in the adoption of one or more of the modern methods of grafting. At East Malling trees have been successfully changed over from one variety to another so as to give ample pollen of the new variety in two years, and a crop of up to five bushels per tree in three years. For this reason no apology is needed for treating the whole subject of grafting in some detail in the following pages, with special emphasis on the frameworking methods which have proved so successful here, and in many commercial plantations throughout the country.

Reasons for grafting.—Growers may substitute one variety of scion for another by means of grafting and this is the reason for most of the grafting undertaken on fruit farms. Re-working, or re-grafting, is preferable to re-planting except where the trees are extremely decrepit. Grafting is also necessary when trees have been girdled by livestock or severely damaged by implements. The root-system as well as the branch-system may be changed by grafting, and though this method is not much practised it is useful in invigorating weakly trees by placing them upon more vigorous rootstocks.

Season for grafting.—The spring is the normal time for grafting with dormant scions, though grafting in various forms is done throughout the year. The methods described here for fruitgrowers are all intended for use from February to June. Early grafting usually gives best results, and late grafting is not advocated, though some forms of grafting with dormant scions are successful in June and after.

The rind of plums and cherries does not readily separate from the wood until very late in the season and these are usually cleft grafted.

Scion-wood (Graft-wood).—One year shoots are selected from prunings of the variety desired. They should be healthy and short-jointed. Water sprouts or sucker growths from the middle of the

trees are unsuitable. Suitable shoots should be collected whilst completely dormant for it is necessary that the stock, or tree to be grafted, should be more advanced in growth than the scion at grafting time.

The selected shoots are tied firmly, with their bases level, in bundles of fifty or less and placed upright in six inches or so of sand or soil on the north side of a building or thick hedge. The heeled-in bundles should be shielded from drying winds by surrounds of sacking or the like, but open to the sky. Collected and stored in this manner scion-wood will remain in good condition until midsummer. Cherry and plum wood, however, usually breaks into growth and does not store well, after the end of April.

Graft seals.—Perfect sealing of grafts is of the utmost importance and very many failures may be attributed to inefficient sealing.

Occasionally unsealed grafts are successful but this should not encourage the operator to regard good sealing unnecessary.

Many sealing materials have been used successfully, but the writer has seen nothing superior to the seals which are applied hot by means of a brush and which set firm on cooling. There are many of these in use; the best melt at above 150° F. and retain sufficient body at considerably higher temperatures, cooling slowly even in cold weather. Seals containing a large proportion of black pitch melt only at high temperatures and cool relatively quickly, often "threading" badly in cold weather.

The following mixture has been well tested:

	lb.	oz.
Resin	5	0
Burgundy pitch	1	10
Tallow	1	4
Paraffin wax	1	4
Venetian red	1	8

The resin and Burgundy pitch are first heated together until melted, and then the paraffin wax and 1 lb. of the tallow are added, and the whole heated together, stirring all the time. When melted and just boiling *the vessel is taken off the fire* and the Venetian red stirred in. A vessel of cold water should be ready, *and the hands well greased with the spare tallow*. Then a portion of the mixture is poured into the vessel of cold water and pulled about as though making toffee, until all the materials are well mixed. If the Venetian red is warmed, before stirring into the melted wax, the air content of the powder will be much reduced and there will be less risk of the material effervescing and overflowing.

A hot fire is required for quickly re-heating the wax, and this may be obtained by burning coke or charcoal in a pail, or small oil drum, in the sides of which numerous holes have been made for ventilation.

Tools.—The most important grafting implement is the knife. This should be of good quality, have a straight-edged blade strongly set in a handle which is large enough to afford a comfortable grip. Cheap knives quickly become loose and useless. A fine carborundum hone will be necessary for sharpening the knife.

A clefting tool is required for oblique cleft grafting. This can be made by any good local blacksmith. If too hard it will fly when struck and if too soft will bend under stress. These tools are often made too large and cumbersome. A useful clefting tool is shown (Fig. 1).

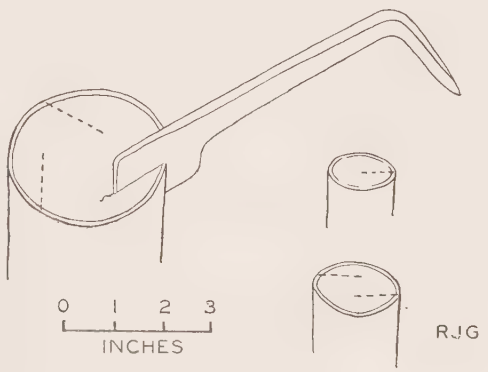

Fig. 1.
Oblique cleft grafting tool.

For methods involving the use of small nails or gimp pins, a supply of these will be required. A useful size for general purposes is $\frac{5}{8}$ inch (gauge 20) gimp pins. A light tack-hammer will also be necessary.

Soft string (fillis) or raffia and possibly some adhesive tape will be required for some of the methods.

The tools and materials may be conveniently carried with the scions in a lap-bag, so that they are always at hand.

A 14 lb. paint tin will hold the wax in sufficient bulk if half filled. The handle should be fixed through the sides of the vessel immediately beneath the rim. Handles are usually soldered on and the solder soon melts when the pot is heated. Old paint vessels may be conveniently cleaned by burning them out upside down over a wood fire provided the vessel is removed immediately the paint has come away and before the solder melts.

Brushes are easily made by tying sisal cord firmly at the ends of sticks and fixing this by driving a gimp pin or tack through the ties into the stick, fraying and trimming to the desired shape. Small brushes with tufts not more than half-an-inch wide and about three-quarters of an inch beyond the stick are best.

Steps and ladders should be provided as required.

Methods of Grafting.—For use on fruit farms, grafting methods may for convenience be placed under the four heads : Frameworking, Topworking, Bridge Grafting, and Inarching.

Frameworking.—*Provision of Pollinators.*—Frameworking has proved to be a rapid and highly successful means of regrafting whole trees of apples, pears, plums and cherries. Further, by the simple methods advocated, particularly the stub graft, it is a useful method of supplying single pollinator branches in individual trees of the established variety.

It is quite common to find orchards or plantations of single varieties. Bramley's Seedling apple has frequently been planted without providing for cross pollination and this variety cannot be relied upon to set regular crops unless other varieties which flower at the same time are near enough for bees and other insects to carry pollen easily to the Bramleys even in cold weather.

Experience teaches the value of cross pollination and in cases of poor cropping, where other conditions are favourable, the introduction of other pollen would almost certainly greatly improve returns. Pollinator varieties should be chosen which blossom freely and annually, at the same time as the main variety. It is important that they should withstand sprays required by the main variety.

In the absence of experimental evidence the optimum proportion of the pollinator is a matter for speculation. It has been suggested that one whole tree in nine is adequate, but the distance of plant is of some importance and it is wise to reckon distance between pollinators as well as quantity. A branch of pollinator at every thirty feet is possibly a reasonable amount. In a fifteen foot plant this would mean a part of every other tree or a branch on every tree at thirty feet square. With ten scions per branch this is rather less than 500 scions per acre. A grafter and waxer can complete four branches per hour, thus requiring twelve and a half hours per acre, which at present wages and costs of material will amount to under £2 per acre, excluding the value of scion material collected at pruning time. By using two ladders the grafter leaves his first ladder in position for use by the waxer, and proceeds to the second ladder which was previously placed in position by the waxer.

General.—The initial cost of frameworking is much higher than topworking but there are some important advantages. Frameworked trees quickly yield large crops of good quality fruit. Pears, plums and cherries have given useful crops in the second season and all properly frameworked trees have cropped heavily in the third season from grafting. Frameworked trees remain healthy in situations where topworked trees may die from diseases such as " Silver Leaf ".

In preparing trees for frameworking a few badly placed branches may be removed entirely, but this work should be kept to a minimum in order to avoid making large wounds and not to disturb the natural growth balance of roots and shoots. The small lateral branches and spurs must be pruned away, except for stub-grafting, and these are replaced at every eight or ten inches along the limbs, right out to the two year wood, with scions. In this way practically the whole of the existing framework of the tree is retained and only the essential fruiting laterals and young extension shoots are replaced with the new variety.

Positions of Scions.—In order to obtain an even growth from all the scions, great precision is required in the placing of grafts. Scions in a vertical position, especially on the inner and top surface of the limb, make stronger growth than those approaching a horizontal position. Very vigorous growth is not needed except where an extension branch is required. Scions on the under side of the limb and in a horizontal position produce the weakest growth. An even scion distribution, placed so as to obtain even vigour comparable with that of a normal tree, is to be preferred.

The placing of scions near the crutch of the tree does not permit of their proper development and they should therefore be at least eighteen inches to two feet from the crutch. Higher up the limbs where it is necessary to put a few scions on the inside of the tree, such should be placed in a lateral position so as to avoid the development of strong growth. Again scions should not be placed in low and outer positions where they may be damaged during cultural operations.

Where stub-grafting is used entirely, there is sometimes a risk of having stubs on one side of the limbs only. This gives an unnatural and one-sided development. Stub-grafts should only be used where the position is suitable, and the gaps should be filled in with side-grafts or inverted L bark-grafts, according to the season.

Stub-grafting.—The tree to be grafted is cleared of all lateral growths, except small lateral branches varying from a quarter to one inch in diameter, which are retained wherever it is desired to have lateral branches of the new variety. This work may be carried out at any time during the

dormant season prior to grafting. Where there is definite danger of infection by the " Silver Leaf " fungus (*Stereum purpureum*) it is considered somewhat safer to defer preparing the trees until the time of grafting.

The scions are prepared with their basal ends cut in the form of a wedge (Fig. 2A). One side of the wedge receives a slightly longer cut than the other. The lateral branch to be grafted receives a cut on its upper side commencing about half-an-inch from the main branch and extending to the base almost to the centre of the lateral shoot. Care must be taken to ensure that the cleft does not extend beyond the centre of the shoot, otherwise the " spring " of the cleft is weakened and the scion will not be held sufficiently firmly. This cut is opened by bending down the lateral and the prepared scion is inserted with the longer side of the wedge downwards (Fig. 2B). It is essential that at least a portion of the cambial tissue of the scion should be in contact with that of the lateral branch into which it is inserted. In order to achieve this when inserting scions into large laterals, it is necessary to place the scion to one side of the cleft. The lateral is released and cut off immediately above the insertion of the scion (Fig. 2C). Upon first attempting this operation some difficulty may be experienced, but with a good knife and after a little practice, it can be satisfactorily accomplished. Some use secateurs, but a knife is preferable. The terminal shoot on each main branch is cut off at the time of grafting, at a point immediately above the uppermost stub-graft. The sealing of all cut surfaces completes the operation.

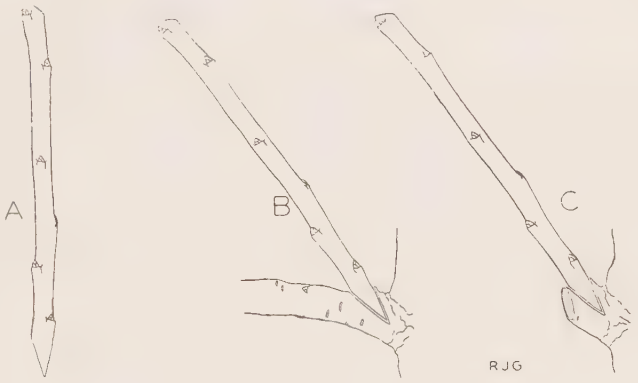

FIG. 2.
Stub grafting.

Side-grafting.—Here scions are inserted direct into the limbs of the tree without recourse to the use of lateral shoots. Comparatively small limbs are more easily side-grafted than those of large size. The trees are prepared by removing all the lateral shoots before grafting and the whole framework is then worked with side grafts. Alternatively, the best placed laterals may be left in and stub grafted, and in that case only the intermediate portions of the limbs are furnished with side grafts.

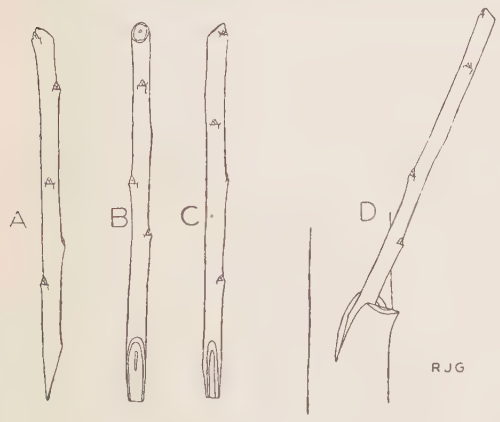

FIG. 3.
Side grafting.

The scions are prepared with the basal ends in the form of an unequally-sided and comparatively long wedge. In preparing the scions advantage should be taken of the slightly " zig-zag " nature of the shoots in order that the scion, when inserted, may stand away from the framework branch as much as possible, so that the angle is approximately that of a lateral shoot. The prepared scion is depicted in text Fig. 3A, B and C. A cut is made into the side of the branch, at an angle of about 20° and never deeper than one-quarter of the diameter of the branch. The cut is opened by slight bending of the branch and the scion is inserted so that its cambium is in contact with that of the framework. The thin lip of bark raised from the branch prior to inserting the graft is cut off after the scion has been pushed home (Fig. 3D). In order to complete the graft it only remains to seal the exposed cut surfaces.

Oblique side grafting.—The scion is prepared (Fig. 4A, B) with two sloping cuts about one inch long made on two sides of the basal end of the scion, and in such a manner that the two cuts meet longitudinally on one side at an angle of 30° to 45°. A shallow oblique cleft is made in the side of the limb (Fig. 4C). This cleft should be slightly deeper than the lateral wedge at the base of the scion. The knife is then partly removed from the cleft to allow the toe of the scion to be inserted. When the scion has entered the cleft, the knife is removed and the scion wedge is then pushed right across the cleft. After sealing the wound the operation is complete. This side graft has proved to be very suitable for working large limbs where the bark is often very thick.

It is particularly important to ensure that in side cleft grafting, as in other methods, the cambial tissues of scion and stock are in contact with each other.

FIG. 4.
Oblique side grafting.

Inverted L *bark grafting.*—Bark grafting must be done when the bark is lifting freely. All lateral shoots and spurs are removed from the tree before grafting begins. The scion is prepared by first making one sloping cut of about one and a half inches in length at the basal end, followed by a very shallow cut at one side just sufficient to expose the cambium (Fig. 5A). The scion is then

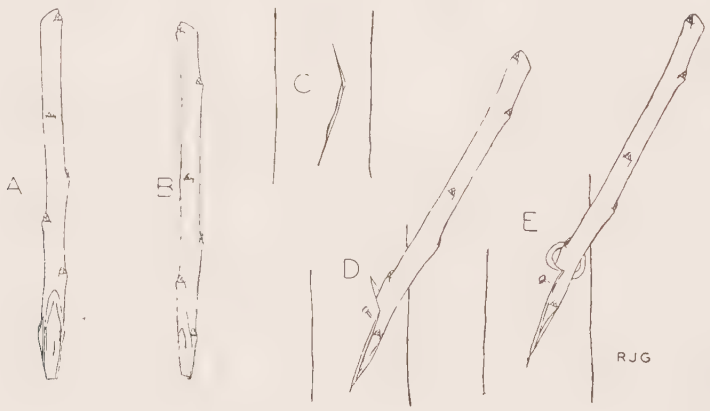

FIG. 5,
Inverted L bark grafting.

reversed and a shallower cut than the first is made a little to the side of the scion away from the small second cut (Fig. 5B). The limb to be grafted now receives a cut as depicted in text Fig. 5C. The term "inverted L" does not accurately describe this cut. In the diagram it will be noted that the longer, or lower, cut is not made in line with the limb, as this would cause the scion to lie along the limb at an unnatural angle, but it is so made that the scion stands away from the surface of the limb. The top cut in the bark is not made at right angles with the lower one but more nearly approaches 150°. It is also cut obliquely into the bark, thus enabling the scion to enter beneath the bark more easily and to fit snugly into position. This modification of the inverted L method allows the bark to fit closely to the scion. The scion is inserted (Fig. 5D) and is held firmly in position by a flat-headed nail or gimp pin, No. 20 gauge and five-eighth inch in length, which is driven right home through the bark and scion into the wood. When the bark of the limb is abnormally thick, three-quarter inch nails of the same gauge are used. It has been found that stouter nails tend to split the scion. Scions may be placed immediately below wounds caused by the removal of lateral shoots or spurs (Fig. 5E). Scions so placed assist the rapid healing of the wounds and the sealing of the graft seals the wound, thus saving both time and material. In sealing this type of graft it is especially important to ensure that water cannot enter between the scion and the limb.

Slit grafting.—This is a simplification of the "awl" or "needle" graft used in various parts of the world. It is successful on apples and pears, where the rind separates readily from the wood. Branches less than an inch thick are not suitable for slit-grafting and may be stub- or side-grafted.

The tree is cleared of laterals. The base of the scion is cut to form a wedge an inch or so long (Fig. 6). A two-inch oblique slit is made along the limb so that the tip of the knife meets the wood of the limb at a tangent.

The scion is pushed into the slit and finds its way between wood and rind. The scion may be set at any desired angle by raising or lowering the apex.

All cut surfaces are sealed ; no tying or nailing is required.

After-care of frameworked trees.—Should the Clay Coloured and closely related weevils prove troublesome by eating the rind and buds on the scions, the tree should be grease banded in the normal way. This prevents those species of weevil from crawling up the trunk from their haunts on the ground. The green and brown leaf-eating weevils, which attack developing leaves, all fly readily ; one or more applications of derris will control them.

In clean cultivated orchards when frameworking has been completed, the soil will be in urgent need of cultivation owing to the treading of the grafters. Care should be taken, during the first few cultivations, that the trees are not shaken severely by horses or tractors as this may dislodge some of the cleft grafts before they become firmly established.

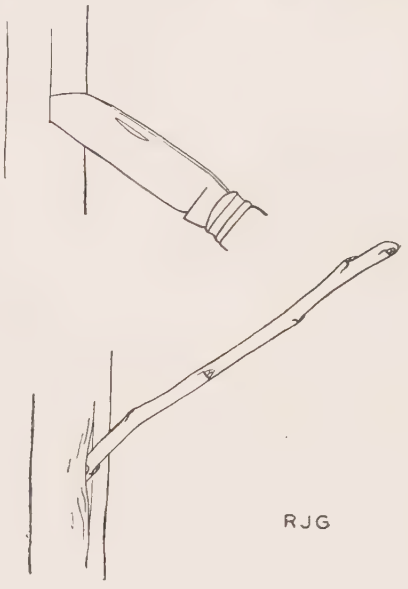

Fig. 6.
Slit grafting.

As the season advances, sucker shoots will arise from the main branches of the old variety, and these should be rubbed out when the longest are less than six inches in length. By this time most of the sucker shoots likely to arise can be removed and it may not be necessary to remove any more until the annual winter pruning. If sufficient scions have been used, very few sucker shoots should arise in later years.

Some experiments have been carried out with summer pinching of scion growth but it is not yet proved that this encourages early fruiting of frameworked trees. This summer pruning, whereby the growth is shortened by one-half, is advantageous in exposed positions, and in windy seasons, when there is a danger of scions blowing out before the grafts become fully established.

Topworking (Top grafting).—Should labour or other difficulties make the practice of frameworking impossible, the old established methods of topworking may be employed. But, although these are cheaper and more rapid in execution, they are much slower to give the desired results, except, perhaps with very young trees.

General.—Much of the main branch system of the tree is removed and scions are inserted in the cut ends of the main limbs within two or three feet of the crutch of bush trees. Correspondingly more framework should be retained in larger trees. A new framework is produced from the scions to replace the old variety. The main limbs may be sawn off at any time during the winter, but fresh cut surfaces will be necessary at grafting time. The preparation of the tree involves considerable labour, and some growers prefer to do this in the winter so that the lop-and-top may be cleared away when labour can best be spared. On the other hand, large wounds should not be made whilst trees are completely dormant, especially in stone fruits and certain apples, such as Newton Wonder, susceptible to "Silver Leaf" disease. Severe pruning also has the effect of delaying growth in the spring.

In preparing trees for topworking it should be remembered that large wounds take a long time to heal, and it is better to insert scions into two small limbs above a crutch rather than in one large limb lower down. Branches of five inches or more in diameter should be sawn off higher up, where their diameter is not more than three or four inches. Eventually it is best if only one scion remains at the end of each limb of the old variety, as this makes for strength at the union. Two or three scions may be inserted in order to retain life at the edges of the cut surface but all except one should be removed as the wound heals.

All small branches below the general level of grafting should be left intact for at least a year in order to feed the roots and retain life in the tree. Such branches are commonly known as "sap-drawers". Experience has shown that where there is a limited amount of "sap-drawers" one or two large branches of the old variety should be left intact for the same purpose. These may be grafted one or two years later, or removed entirely when growth from the new scions is abundant.

Newly inserted scions are often damaged by the Clay Coloured and closely related weevils which

eat the rind and the buds. Such insects may be controlled by painting the scions with a cream of lead arsenate paste and water immediately after grafting.

Oblique cleft grafting.—The latter part of February is not too early to begin cleft-grafting and the work may continue as long as the scion-wood remains in good condition, having in mind that in general early grafting is preferable.

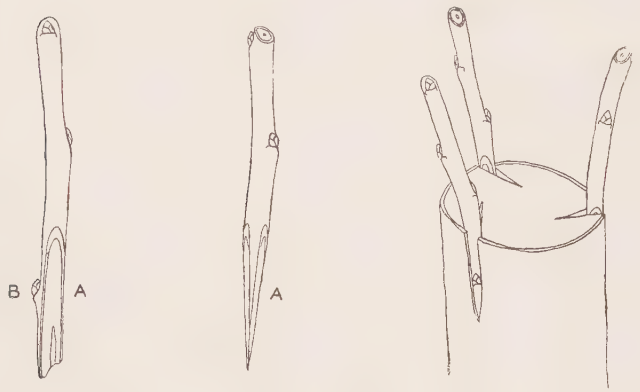

FIG. 7.
Oblique cleft grafting.

The sawn ends of the limbs are pared smooth, at least near the edges and cleft as shown in Fig 1. None of the clefts should extend right across the branch.

Three- or four-bud scions are used. The upper end is cut immediately above a bud and the lower is prepared by two slanting cuts in the form of a long tapering wedge (Fig. 7A). The presence of a bud (B) between the two cut surfaces, and about halfway between the point at which the cuts begin and the base of the scion, is an advantage.

The clefts are opened by means of the grafting tool and the scions are inserted, care being taken to see that the cambiums are in contact. The exposed cambium of the scion is not strictly in line with the scion, so a slight inclination outwards of the top of the scion gives more opportunities for cambium to meet. Removal of the tool causes the scion to be held firmly in position and no tying or nailing is necessary. All cut surfaces including the apical ends of the scions, and the cut surfaces of limbs, are sealed with grafting wax. Careful workers rub a little clay into the clefts to prevent the wax from running down inside where it might prevent healing.

If the trees are in an exposed position the "leaders" or main shoots from the scions may be steadied during the first year by tying them loosely to stakes bound tightly to the branches of the tree.

Rind grafting (*Crown graft*).—This is another method of top grafting. The sawn ends of the limbs are pared smooth and the scion is inserted between the rind and the wood of the trees. The rind should part readily from the wood, a condition not normally reached in this country until after early April.

There are many methods of preparing and inserting the scion. In the most common, the scion is prepared as for whip and tongue grafting but without the tongue (Fig. 9). The prepared limb receives a cut of one or two inches in length extending downwards from the pared surface of the limb, and the scion is pushed down beneath the rind so that the cut surface of the scion is towards the middle of the limb (Fig. 8). The rind may be first lifted by means of a thin bone spatula such as can be made from an old toothbrush handle. The limb receives from one to four scions according to its size.

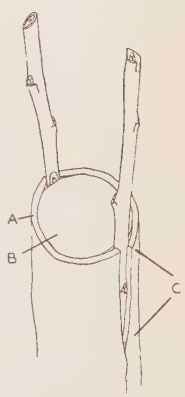

FIG. 8.
Rind grafting.

Unlike the oblique cleft the rind graft must be tied firmly with soft string, raffia or tape around the end of the limb over the inserted scions, avoiding the stock- or basal-bud of the scion. If waxed tape is used for binding, it will only be necessary to seal the remaining exposed cut surface at the end of the branch and the tips of the scions, otherwise all cut surfaces, including the bark opening over the inserted scion, must be sealed as in oblique cleft grafting.

Soft string is usually more convenient to use than raffia, especially on large limbs. Raffia and some adhesive tapes usually burst with the growth of the tree, but to avoid constriction the string may have to be cut by the middle of the summer. The work should be inspected from time to time.

Staking of the growths from the scions may be necessary as described under oblique cleft grafting.

Whip and Tongue grafting.—This is the graft so much used in fruit tree nurseries and is one of the simplest and most successful methods of uniting scion and stock when these are about the same size. It can be used at almost any time, but March-April is the best time.

The method is useful for topworking young trees where the branches are not more than an inch thick, and an ideal method where stock (branch) and scion are of equal size. If the stock is much larger than the scion it is only possible to match one side of the scion with one side of the stock in such a manner that the cambial layers are in contact.

Three- or four-bud scions should be used (Fig. 9). A flat slanting cut two inches long is made at the basal end. A downward pointing tongue is made in the apical half of this slanting surface. A slanting cut of similar length is made upwards through the branch where the new scion is required. An upward pointing tongue is made in the apical half of this surface. The tongues of scion and branch are interlocked so that the cambial regions are in contact over as great a length as possible. Careful tying is necessary with raffia or tape, taking care that the scion is not displaced and cambiums separated. In waxing all cut surfaces, and the ties over the parts of the scion in contact with the stock-branch, the ties at the back of the stock-branch should not be covered. This permits easy cutting of the ties when constriction is likely to occur, at the end of May or early June. The severed ties should not be unwound for fear of disturbing the union. Some adhesive tapes often burst without constriction but care is necessary to see that this occurs in all cases. Sealing taped whip and tongue grafts with wax is not essential, but it is always an advantage to seal the apical end of the scion and wax or grease is required for this. Sometimes staking may be necessary as with other methods of topworking.

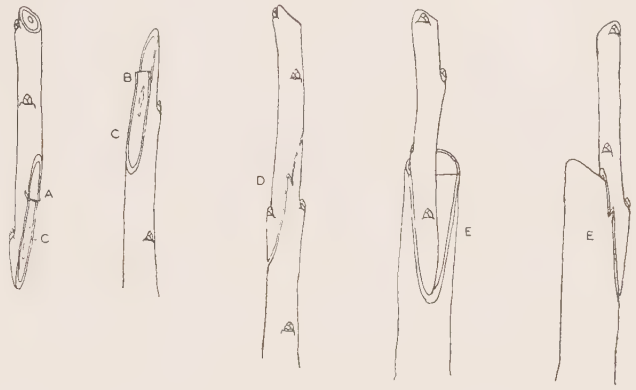

Fig. 9.
Whip and Tongue grafting.

Bridge grafting.—When trees have been completely girdled by animals, implements or canker, the trees die unless branches and roots are reconnected. Death may not occur until one or two years after girdling because nutrients pass up in the undamaged wood and enable the leaves to function, but eventually the roots die because no food returns to them via the bark. Reconnection of the girdled bark saves the tree. Girdling is not always complete, either around the tree or down to the wood, and in these cases bridge grafting is not necessary, but when in doubt it should be done and regarded as an inexpensive form of insurance. If the bark has been eaten away down to ground level, the soil should be removed to expose sufficient undamaged surface and replaced after grafting.

The rough edges of the bark may be trimmed, and, if girdling is due to canker, all discoloured tissue must be pared away before grafting.

Dormant scions of sufficient length for ease of manipulation are required. When the girdled area is of great length the scions may not be long enough and it will be necessary to splice two scions together by whip and tongue grafting. Small trees an inch or so in diameter can be saved by one bridge. Larger trees should have one bridge for every inch of diameter. Thus a trunk six inches thick would have five or six bridges.

There are many ways of inserting the scions. One of the simplest which has proved successful is the inverted L bark graft (Fig. 5) used in frameworking. Insert the lower end first, a few inches below the girdle and nail firmly in position ; then prepare and insert the apical end a few inches above the girdle in a reversed incision. Short scions and those that are extra stout are difficult to manipulate. It is easier to obtain a good fit if the bridge is bowed outwards and this is aided by inserting a tapered piece of wood, one and a half to two inches thick, between the tree and the bridge until the graft is nailed home.

Very small trees are not conveniently bark grafted. These may be bridged by side cleft grafting as advocated for side grafting small branches in frameworking (Fig. 6). Here the cleft is not made so deep into the wood and the graft requires tying firmly with tape, string or strong raffia.

All cut surfaces should be sealed, taking care that no holes are left for the entry of water between the bridge and the tree at the graft.

Immediately each tree is grafted it should be protected from further damage. Efficient wiring of the whole piece will prevent damage by rabbits but tree guards will be necessary to protect orchard trees against grazing animals. Implements and spray hoses cause damage to bridges, particularly whilst young, and stakes should be used to guard against this.

Young growths from the bridges should be rubbed out as they appear, and the tying material, used on small trees, adjusted or removed before constriction occurs.

Inarching (Approach grafting).—Where the use of unsuitable rootstocks or damage to the roots has resulted in stunted trees it is often possible to improve growth by inarching into them more vigorous rootstocks which eventually take over the duties of the original roots.

Two rootstocks placed on opposite sides of the tree should be sufficient. From recent experiments it appears that the stocks should be inserted in line with the crutch between the major branches in order to distribute the effect of each of the inarches to more than one branch. Trunks of trees frequently exhibit torsion and the lines of growth should be followed from the crutches downwards in choosing points for inarching.

The inarch should be made as low as convenient. The rootstock may be planted either during the winter or at grafting time in April. In order to hasten the growth of the new roots a fairly large hole should be opened, between the existing main roots, and filled with top soil in which has been incorporated some rotted dung or humus. The rootstock should be planted firmly. If planted at grafting time the graft may be completed before placing soil around the rootstock. The method of insertion is as described for the apical ends of bridge-grafts, and inarches should also be similarly protected and disbudded.

Summary.—Simple methods of Frameworking, Topworking, Bridge grafting and Inarching for use by fruit growers are described with the assistance of drawings.

The collection of scion-wood, suitable graft seals and tools are also described.

INSECTICIDES AND FUNGICIDES

THE EAST MALLING SPRAY CALENDAR, 1942 EDITION

By M. H. MOORE and W. STEER

It is eight years since the first edition of the East Malling Spray Calendar appeared. During these years pest control has undergone many changes, some of detail only but others of far-reaching importance. We have long felt the need for a new edition and have met this to some extent by making additions and alterations to all copies sold in recent years. This practice proved unsatisfactory, however, and we are now providing our members with a completely new version, in which scarcely one of the original recommendations remains unchanged.

Chief among the newer developments are the D.N.C. winter wash, which is now firmly established as an alternative to tar and petroleum washes, and the nicotine vapour method of controlling aphis which, though not yet so familiar, will, we believe, make an important contribution to strawberry growing. Changes have been made in the concentrations advised for several spray methods and in their timing. Some materials, such as the colloidal sulphurs and coppers, whose usefulness had not been thoroughly established when the Calendar was first issued, are now included. The chief change in the recommendations for Hops is the use of lime-sulphur to control Red Spider, and, for plums and cherries, the use of copper sprays against Blossom Wilt and Bacteriosis. Advantage has been taken of some increase in our knowledge of spray damage, e.g. the cautionary note regarding mixtures of lead arsenate with very weak lime-sulphur.

Several features of the old Calendar have been sacrificed. The left hand columns, which served not only as a key to the several spray materials but showed also the periods at which they are in greatest demand, are now replaced by a simple key, thus making room for groups of notes that amplify the information contained in the body of the Calendar.

The use of colours has been dropped, though not without regret. The convention of red for fungicides and diseases, and blue for insecticides and insect pests had become more and more difficult to maintain and, in any case, an elaborate, coloured production would be out of keeping with wartime austerity.

To the criticism that the present production is too flimsy to withstand frequent thumbing, we reply in advance that the old one was a great deal too durable and possibly outlived its usefulness.

We hope that our new Calendar (which was up to date when it went to press!) will survive several seasons without much change. The paper is unvarnished, and so such alterations or additions as may from time to time become necessary can easily be made. Incidentally our members will, we are sure, surrender their copies of the old Calendar for pulping, and so make good the quantity of paper we have expended on the new one.

Finally, although it has fallen to us to edit this Calendar and to accept responsibility for any of its shortcomings, we gratefully acknowledge the very valuable help and advice that we have received from many of our colleagues on the Staff here, not only pathologists but others too. The calligraphy and the printing were undertaken by Messrs. Technical Products Ltd., to whom we take this opportunity of expressing our thanks.

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EAST MALLING RESEARCH STATION

SPRAY CALENDAR

1942 EDITION.

1942 EDITION.

NOTES.

STAGES IN APPLE & PEAR

Budburst — Greenbud — Pinkbud (Apple) Whitebud (Pear)

The date and duration of these stages and of the blossom periods depend on variety and season and may differ from those given in the calendar

KEY

Dotted arrow - - - - - → One treatment only during period indicated.

Continuous arrow ——— → Repeated treatments (as and when required) during period indicated.

T	Tar oil.
DNC	Dinitrocresol.
B	Bordeaux mixture *
CC	Colloidal copper. §
L	Lime sulphur
CS	Colloidal sulphur §
S	Sulphur (flowers or dust)
A	Lead arsenate powder
N	Nicotine (95/98% purity) †
D	Derris ‡
W	Warm water treatment.

* The strength is shown by two figures, thus 4:6 indicates 4 lb. bluestone and 6 lb hydrated lime per 100 gallons

§ Use at strengths recommended by the makers. These and other satisfactory preparations of copper and of sulphur - some in dust form - are easy to handle and are of special value since they leave no unsightly deposits on the fruit.

† When using nicotine in vapour form (eg for Strawberry Aphis) special machinery is needed Such work is best done by special contractors.

‡ Derris and other rotenone-containing roots (e.g. Lonchocarpus) are obtainable in the form of finely ground powders. In general, use enough to yield 0·005 per cent of rotenone in the wash; the strength (2 lb) suggested in the calendar is the maximum likely to be required.

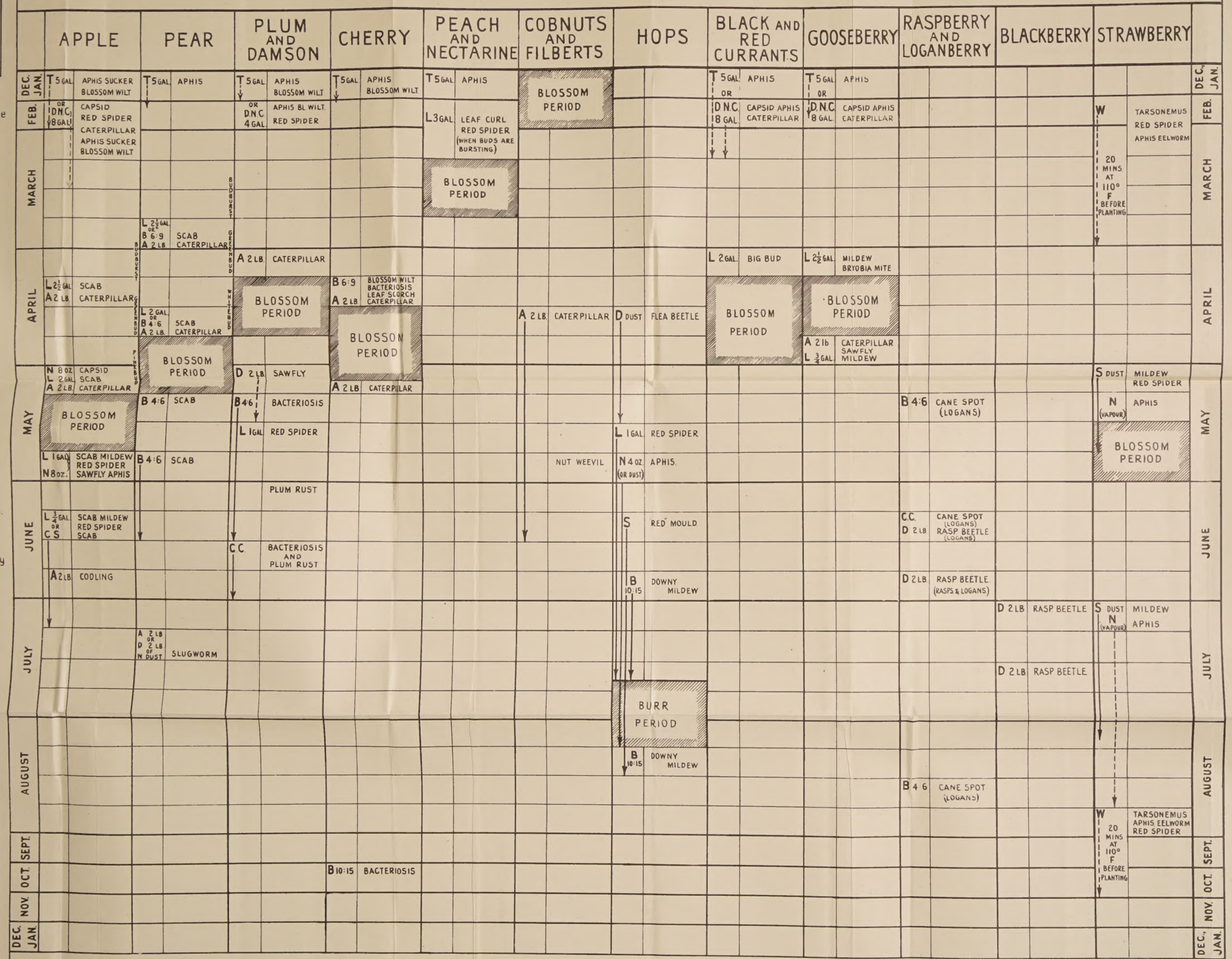
MIXED WASHES.

Where several materials are recommended for use at any one time they can be combined in one wash. Exceptions to this are obvious e.g. 'L' and 'B' under hops and 'S' dust and 'N' vapour' under strawberries

Though usually unnecessary for a mixed wash, a good wetter (eg soap) is needed when nicotine or Derris is used alone

Soap must not be mixed with lead arsenate, Bordeaux mixture, or lime sulphur. If lead arsenate and a wash containing soap are used within two weeks of each other, damage may occur

Lead arsenate used with weak lime sulphur (i.e. up to one per cent) can cause severe fruit drop


APPLE
PEAR
PLUM AND DAMSON
CHERRY
PEACH AND NECTARINE
COBNUTS AND FILBERTS
HOPS
BLACK AND RED CURRANTS
GOOSEBERRY
RASPBERRY AND LOGANBERRY
BLACKBERRY
STRAWBERRY
DEC. JAN.
FEB.
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPT.
OCT.
NOV.
DEC. JAN.
T 5 GAL APHIS SUCKER BLOSSOM WILT
OR D.N.C. 8 GAL CAPSID RED SPIDER CATERPILLAR APHIS SUCKER BLOSSOM WILT
T 5 GAL APHIS
T 5 GAL APHIS BLOSSOM WILT
OR D.N.C. 4 GAL APHIS BL WILT. RED SPIDER
T 5 GAL APHIS
L 3 GAL LEAF CURL RED SPIDER (WHEN BUDS ARE BURSTING)
BLOSSOM PERIOD
BLOSSOM PERIOD
T 5 GAL APHIS OR D.N.C. 8 GAL CAPSID APHIS CATERPILLAR
T 5 GAL APHIS OR D.N.C. 8 GAL CAPSID APHIS CATERPILLAR
W TARSONEMUS RED SPIDER APHIS EELWORM
20 MINS AT 110° F BEFORE PLANTING
L 2½ GAL OR B 6:9 A 2 LB SCAB CATERPILLAR
A 2 LB CATERPILLAR
L 2 GAL BIG BUD
L 2½ GAL MILDEW BRYOBIA MITE
L 2½ GAL A 2 LB SCAB CATERPILLAR
L 2 GAL OR B 4:6 A 2 LB SCAB CATERPILLAR
BLOSSOM PERIOD
B 6:9 A 2 LB BLOSSOM WILT BACTERIOSIS LEAF SCORCH CATERPILLAR
BLOSSOM PERIOD
A 2 LB CATERPILLAR
D DUST FLEA BEETLE
BLOSSOM PERIOD
BLOSSOM PERIOD
A 2 lb CATERPILLAR SAWFLY
L ¾ GAL MILDEW
N 8 OZ. L 2 GAL A 2 LB CAPSID SCAB CATERPILLAR
BLOSSOM PERIOD
B 4:6 SCAB
D 2 LB SAWFLY
B 4:6 BACTERIOSIS
L 1 GAL RED SPIDER
A 2 LB CATERPILLAR
L 1 GAL N 8 OZ. SCAB MILDEW RED SPIDER SAWFLY APHIS
B 4:6 SCAB
NUT WEEVIL
N 4 OZ (OR DUST) APHIS.
L 1 GAL RED SPIDER
S DUST MILDEW RED SPIDER
N (VAPOUR) APHIS
B 4:6 CANE SPOT (LOGANS)
BLOSSOM PERIOD
PLUM RUST
L ¼ GAL OR C S SCAB MILDEW RED SPIDER SCAB
S RED MOULD
C.C. D 2 LB CANE SPOT (LOGANS) RASP BEETLE (LOGANS)
C C BACTERIOSIS AND PLUM RUST
A 2 LB CODLING
B 10:15 DOWNY MILDEW
D 2 LB RASP BEETLE (RASPS & LOGANS)
D 2 LB RASP BEETLE
S DUST MILDEW N (VAPOUR) APHIS
A 2 LB OR D 2 LB OR N DUST SLUGWORM
D 2 LB RASP BEETLE
BURR PERIOD
B 10:15 DOWNY MILDEW
B 4 6 CANE SPOT (LOGANS)
W 20 MINS AT 110° F BEFORE PLANTING TARSONEMUS APHIS EELWORM RED SPIDER
B 10:15 BACTERIOSIS

NOTES

ALL REFERENCES IN THIS CALENDAR ARE TO WET SPRAYS UNLESS OTHERWISE STATED, AND ALL QUANTITIES ARE PER 100 GALLONS. WHEREVER POSSIBLE USE MATERIALS THAT CONFORM TO SPECIFICATIONS PUBLISHED BY THE MINISTRY OF AGRICULTURE.

WINTER WASHES.

D.N.C. wash is a petroleum emulsion with which is incorporated a dinitrocresol to do the work of tar oil. D.N.C. can therefore replace tar and petroleum emulsions where Capsid, Red Spider Caterpillar, Aphis, Sucker and Blossom Wilt are all to be controlled. Where it is likely that only part of the acreage can be sprayed within the period shown (February - early March) spray the other part in December - January with tar wash and again, in late March, with petroleum.

TAR OIL is for Aphis, Sucker and Blossom Wilt only.

PETROLEUM OIL is for Capsid, Red Spider and Caterpillar only. For Capsid, 6½ % is sufficient *in late March but in February 8% is needed.* For Spider half these strengths should suffice Apply in calm weather and at least two weeks before the green bud lime sulphur wash.

SPRING AND SUMMER WASHES.

Copper sprays are recommended for post-blossom use on Pears, but are unsafe on most apples at any time. Where apples are interplanted with Pears lime sulphur can conveniently be used on both.

In many districts lime sulphur is harmful, especially post-blossom, to the following Apples - Stirling, Lanes Belle de Boskoop, Duchess's Favourite, St. Cecilia, Newton, Rival. Of these only Newton needs regular post-blossom spraying for Scab.

Other varieties that seldom require any post-blossom treatment for Scab are :- Grenadier, Gladstone, Early Victoria, Derby, Chas. Ross, Edward VII, Millers, Monarch.

On the varieties mentioned above, summer petroleum (1 gal.) used post-blossom in place of lime sulphur will kill Red Spider. On plums, this petroleum can be combined with the Derris used for Sawfly.

For Mildew on sulphur-shy Gooseberries (e.g. Leveller, Yellow Rough) use washing soda (20 lb.) and soft soap (5 lb.) post blossom in place of lime sulphur.

BIG BUD.

The 2% lime sulphur recommended is intended to keep "clean" plantations clean. Severely infested bushes, if they are worth saving at all, will need up to 8%. The Goliath group is sulphur-shy.

THIS CALENDAR IS INTENDED AS A GUIDE - THE DETAILS CAN BE MODIFIED TO SUIT YOUR OWN CONDITIONS